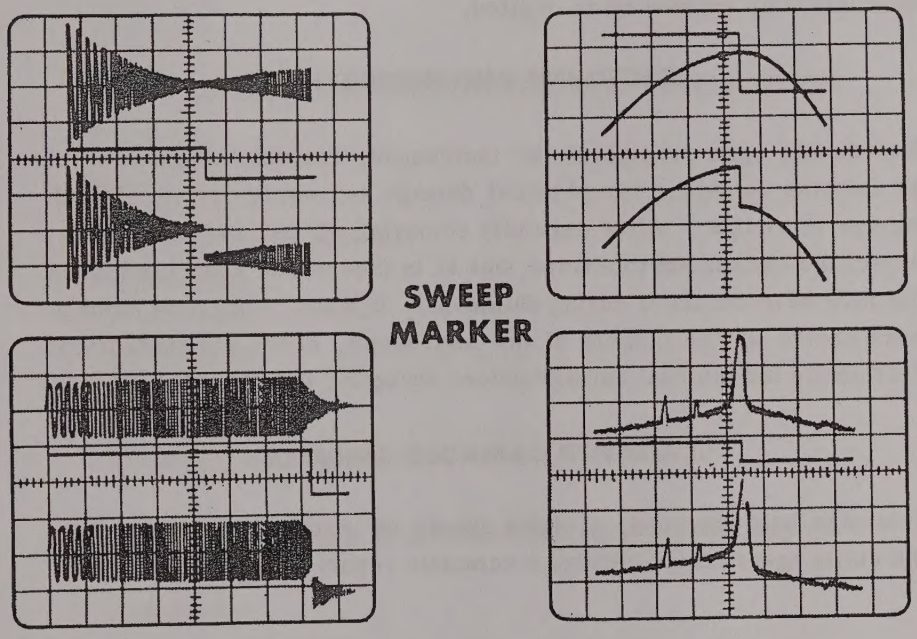
Operation & Maintenance MANUAL



SERIES 40 FUNCTION GENERATOR

Model No. _____

Serial No. _____

INTERSTATE ELECTRONICS CORPORATION
SUBSIDIARY OF ATO
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Department 7000

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Revised: 1977

Part No. P0034099
Revision A

WARRANTY

Interstate Electronics Corporation warrants its function generators against defects in material and workmanship for a period of one year from date of shipment. We will repair or replace defective products during the warranty period provided that such defect developed under normal and proper use and that transportation costs are paid by the purchaser. We are not liable for consequential damages nor is any other warranty expressed or implied.

RECEIVING AND INSPECTION

Immediately upon receipt of the instrument, inspect the exterior of the shipping container for physical damage and notify carrier if such damage is visible. After carefully removing all packing materials, inspect the instrument to ensure that it is free of mars and blemishes that may have occurred during shipment. If there is physical damage to the carton or the outside of the instrument, check the instrument functionally for internal damage before accepting the shipment.

CLAIM FOR DAMAGED SHIPMENT

If damage has occurred, a claim should be made with the carrier. The claim agent should receive a complete report of damage.

CALIBRATION AND REPAIR SERVICE

IEC maintains a trained staff of engineers and technicians for assisting customers in out-of-warranty service.

POWER

This instrument operates from a-c power only, either 115 or 230 Vac, 50 to 400 Hz. A slide switch at the rear of the equipment readily selects the desired power line voltage. A NORMAL/LOW switch is provided for use with extremely low-line voltages (100 or 200 Vac ±10 percent).

CAUTION

Operation at the wrong power line voltage switch setting may damage the instrument or blow fuses.

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Section 1
SPECIFICATIONS AND INSTALLATION

1-1. INTRODUCTION

This manual has been carefully prepared to complement the actual hardware design features of your IEC SERIES 40 function generator by providing data on its operation and performance. The manual provides the operator with an understanding of the functions of the units and specifications. It should be noted that the function generators have been designed so that constant reference to the manual is not necessary to operate the equipment.

1-2. DESCRIPTION

Your IEC SERIES 40 function generator is a state-of-the-art signal source designed for great versatility, maximum ease of operation, and long operational life.

The case enclosing the equipment provides exceptional physical ruggedness and utility together with effective electrostatic shielding. The latter is important for the radio-frequency operating ranges of the instruments. Attention has been given to ground isolation applications, and a grounding switch is provided at the rear of each instrument.

The serial number and other identification data are located at the rear of the instrument. The rear panel also serves as the primary heatsink for the instrument.

1-3. RECEIVING AND INSPECTION

Immediately upon receipt of the instrument, inspect the exterior of the shipping container for physical damage and notify the carrier if such damage is visible. After carefully removing all packing materials, inspect the instrument to ensure that it is free of mars and blemishes that may have occurred during shipment. If there is physical damage to the carton or the outside of the instrument, check the instrument functionally for internal damage before accepting the shipment.

Refer to Verification of Operations, paragraph 1-9, for simple, step-by-step instructions for turn on and preliminary operation.

1-4. INSTALLATION

This instrument may be used on the workbench or rigidly mounted in a RETMA rack structure by means of an optional rack-mounting kit. As initially shipped, the instrument has a bottom-mounted tilt mechanism for optimum panel viewing angle. The feet must be removed for proper rack mounting.

This all solid-state instrument requires no special cooling facilities when operated within the specified temperature limits. Care must be taken to ensure that a 2-inch minimum clearance is provided at the rear of the instrument along with sufficient ventilation for proper convection cooling of the heatsink.

1-5. POWER REQUIREMENTS

This instrument operates from a-c power only, either 115 or 230 Vac (±10%), 50 to 400 Hz. A slide switch at the rear of the equipment readily selects the desired power line voltage. Fuses for the instrument are contained in a separate envelope. Install the proper fuse for the line voltage selected.

CAUTION

Operation at the wrong power line voltage switch setting may damage the instrument.

On those instruments supplied with slide switches for selecting normal- or low-line voltage operation, the following chart indicates the proper switch settings.

OPERATING RANGE		
Line	Norm	Low
115V	126	110
	104	90
230V	252	220
	208	180

A three-conductor cord is supplied with the equipment to permit referencing the chassis and case to power system ground. This safety feature is recommended by the National Electrical Manufacturers Association (NEMA). The offset pin on the power cord connector is the ground wire. Generator circuitry (including input and output BNCs) may be isolated from the case ground by operating a slide switch on the back panel of the instrument.

1-6. REPACKAGING

If it becomes necessary to reship the instrument, contact your IEC representative. The following procedure is recommended for packing the instrument for shipment:

a. Attach a tag bearing the owner's name, address, and telephone number together with a brief description of the purpose of the shipment and the date its return is desired.

b. Wrap the equipment in heavy paper or plastic before placing it in an inner container.

c. Liberally use soft packing material around all sides of the instrument inside the inner container.

d. Enclose the inner container in a rugged carton or wood box with suitable packaging material to prevent movement in any direction and seal the outer container with heavy tape or metal bands.

e. Mark the shipping container with the shipping address and "DELICATE INSTRUMENT" labels. Shipping must be prepaid.

1-7. DISASSEMBLY

To remove the function generator from its case, remove the two 6-32 retaining screws mounted in the bottom of the case at the rear of the unit and slide the electronics forward.

1-8. SPECIFICATIONS

The following data sheet provides the specifications on the F41, F43, F44, F46, and F47 function generators. While this data sheet represents the most accurate specifications available at the time of publication, IEC

reserves the right to modify the specifications at any time and to note such modifications in an errata page at the back of this manual.

1-9. VERIFICATION OF OPERATIONS

Indication of function generator operation can be verified with the use of a Tektronix Type 454A oscilloscope or the equivalent.

NOTE

The oscilloscope should have high-frequency capability (preferably 50 MHz or greater) to permit viewing higher-order harmonics of square wave and pulse signals, and should be dual trace. Dual trace is required to permit use of the marker-frequency calibrator feature of the IEC SERIES 40 function generators.

Connect the function generator to the oscilloscope (using BNC terminated coaxial cables) as noted in the next column.

Function Generator	Oscilloscope
Output (Front Panel Ref 12)	Channel 1
(Use 50-ohm, 2-watt feed-through load)	
Sweep Sync (Back Panel Ref 4)	External Trigger Input
Marker Step (Front Panel Ref 21)	Channel 2

Table 1-1 outlines the control (knob) positions and the results to be observed at the output by model.

TABLE 1-1. VERIFICATION OF OPERATIONS

Step	Control	Ref	Position	Results	Comments
1a	Frequency Dial	2	Approx 0.4	Set up	
b	Sweep/Calib Limit Dial	4	Approx 3.0	Set up	Not on F46
c	Frequency Multiplier	5	100K	Set up	
d	Var Sym/Norm/0.01f Control	6	NORM	Set up	See note 1.
e	Mode	7	CONT	Set up	NORM on F41
f	Trigger Level	8	midrange	Set up	Not on F41
g	Waveform	9	∿	Set up	
h	Var Sym/Pulse Width	10	midrange	Set up	See note 1.
i	Phase	20	midrange	Set up	See note 1.
j	Step Calibrator	18	MKR	Set up	Not on F44, F46
k	Sweep Marker	17	midrange	Set up	F44, F47 only
l	Offset/Pull On	16	Push in (midrange)	Set up	
m	Sweep Time	13a	1 ms	Set up	F44, F47 only
n	Sweep Time Vernier	13a	midrange	Set up	F44, F47 only
o	Log/Lin Switch	15a	LIN	Set up	F47 only
p	Output Level	11	-20 dB	Set up	
q	Output Level Vernier	11	midrange	Set up	See note 1.
	Refer to paragraph 1-9 for connections to oscilloscope.				

Note:

1. Place small concentric control knob in midrange (position indicator up).

Table 1-1. Verification of Operations (Continued)

Step	Control	Ref	Position	Results	Comments
2a	Oscilloscope channel selector		Channel 1 (or A) only	Set up	
b	Oscilloscope vertical sensitivity		Approx 0.2V/div	Set up	
c	Oscilloscope trigger mode		Internal positive	Set up	
3	Oscilloscope positioning controls			Continuous sine wave, approx 40 kHz, 4 div p-p centered around zero d-c voltage reference. Bipolar, see note 2.	Center 40-kHz sine wave on crt approx 4 cycles, approx 4 div p-p
4	Waveform (rotate ccw 1 position)	9		Continuous sine wave, approx 2 div p-p. Positive unipolar (see note 3) zero-based.	
5	Waveform (rotate ccw 1 position)	9		Continous sine wave, approx 2 div p-p negative unipolar zero-based (see note 3).	
6	Waveform (rotate ccw 1 position)	9		Continuous variable symmetry square wave or variable-width pulse. Bipolar, zero-based, approx 4 div p-p (see note 2).	See note 2. Also see step 7.

Notes:

2. Bipolar signal in CONTinuous mode is symmetrically positioned around the d-c offset voltage (if any) independent of waveform.
3. Unipolar positive or negative waveform feature of IEC SERIES 40. Unipolar waveforms are approximately half amplitude with the peaks closest to 0 volt clamped at the d-c baseline reference. DC baseline is affected by the OFFSET (and PHASE control for sine and triangle waveforms in TRIG and GATE modes).

Table 1-1. Verification of Operations (Continued)

Step	Control	Ref	Position	Results	Comments
7	Pulse Width	10	Rotate end to end cw, then ccw.	Pulse width varies over a range of 5% to 95%. Remains bipolar (see comment).	May lose waveform at extremes of rotation.
8	Pulse Width	10	Return to midrange.	Pulses approx 50:50 duty cycle	
9	Waveform (rotate ccw 1 position)	9		Continuous pulse train, unipolar positive, approx 2 div p-p	See note 3.
10	Pulse Width	10	Rotate partially cw, then partially ccw.	Pulse width varies without changing zero reference	See note 3.
11	Offset/Pull On	16	Pull on and rotate slightly both directions.	Pulse base d-c level is controlled independently of duty cycle.	See note 3.
12	Pulse Width	10	Rotate slightly both directions.	Pulse duty cycle is controlled independently of d-c level.	See note 3.
13	Pulse Width and Offset	10 16	Center both controls to midrange; push in Offset.	Same as 9 above	
14	Waveform (rotate ccw)	9		Continuous pulse train, unipolar negative similar to 9 above	See note 3.
15	Waveform	9		Continuous symmetrical, bipolar square wave, zero d-c base, approx 4 div p-p	See note 2.

Table 1-1. Verification of Operations (Continued)

Step	Control	Ref	Position	Results	Comments
16	Waveform (rotate cw 1 step)	9		Continuous symmetrical, bipolar triangle wave, zero d-c base, approx 4 div p-p	See note 2.
17	Waveform (rotate cw 1 step)	9		Continuous symmetrical, unipolar positive triangle wave, approx 2 div p-p	See note 3.
18	Waveform (rotate cw 1 step)	9		Continuous symmetrical, unipolar negative triangle wave, approx 2 div p-p	See note 3.
19a	Waveform (rotate cw 1 step)	9	DC		
b	Adjust scope trig to show d-c trace			Horizontal line on scope	
c	Offset/Pull On	16	Pull on and rotate both directions.	Output changes d-c level (no a-c signal).	
20a	Waveform	9		Set up	
b	Offset/Pull On	16	Push in, set indicator to midrange.	Set up	
c	Oscilloscope				Adjust for sine wave approx 4 div p-p, 40 kHz
21	Frequency Dial	2	Vary over range. Return to 0.4.	Frequency varies.	Frequency tuning is operating.
22	Frequency Multiplier	5	Vary over 6 ranges; return to X100K.	Frequency varies.	Frequency ranges are operating.

Table 1-1. Verification of Operations (Continued)

Step	Control	Ref	Position	Results	Comments
23	Log/Lin Switch	15a	Switch to logarithmic.	Frequency changes to inner calibration on frequency dial.	F47 only. Shows LOG feature is operating.
24a	Log/Lin Switch	15a	LIN	Set up	F47 only
b	Mode	7	Continuous sweep	Set up	F44, F47 only
c	Sweep/Calibrator Limit	4	4.0	Set up	
25a	Oscilloscope Trigger Mode		External, negative (-)	Set up	Use SWP SYNC from rear panel, figure 2-2(4). See note 4.
b	Oscilloscope Trace Selector		Alternate mode	Channel 1: Sweep, low to high frequency left to right, approx 40 kHz to 400 kHz. Channel 2: Sweep Marker step.	For channel 1 see note 5. For channel 2 see note 6.
26	Sweep Marker	17	Vary control cw/ ccw and return to midrange.	Marker step will vary along the swept frequency.	See note 6.

Notes:

4. Caution: oscilloscope must synchronize on sweep-time period via rear panel output sweep sync signal. When in continuous sweep mode, the output frequency is not synchronized with the sweep time. However, if desired for viewing on an oscilloscope, a small change in the frequency dial will generally permit freezing the sweep frequency on channel 1.

5. Caution: be certain that the vertical time coincidence of channel 1 and channel 2 is preserved. If in doubt, use chopped mode to verify.

6. The calibration marker may not appear to extend fully to the highest frequency. This is an illusion caused by the presence of retrace frequencies. See paragraph 2-3e and 2-3h for discussion on retrace times and marker pulse behavior during retrace.

Table 1-1. Verification of Operations (Continued)

Step	Control	Ref	Position	Results	Comments
27	Mode	7	Calibrate.	Continuous sine wave at frequency where calibration step was positioned from previous step	Shows Marker Calibration mode is operating. See note 7.
28	Step Calibrator	18	Sweep start (F47), low limit (F41, F43)	Continuous sine wave at frequency of main cursor	Scope not synchronized unless switched to internal sync.
29 to 38	Step Calibrator	18	Rotate cw 1, 2 3 . . . sweep stop (high limit).	Continuous sine wave with increasing frequency at each step	Shows Step Calibrator is operating
39a	Sweep Time	13a	1 second to 100 seconds	Set up	F44, F47
b	Mode	7	Triggered sweep	Set up	
c	Sweep Time Vernier	13a	To approx 9 o'clock	Set up	
40a	Oscilloscope Trace Selector		Channel 1 (only)	Set up	
b	Oscilloscope Trigger Mode		Internal sync	Set up	
c	Oscilloscope Time Base		0.1-ms	Set up	
d	Manual Trigger	19	Push	Continuous sine wave sweeping at slow (approx 10 seconds) rate from low to high frequency	Shows Trigger, Triggered Sweep, and Manual Trigger are operating.

Note:

7. A principal feature of IEC Models F44 and F47 is the use of the sweep marker to permit immediate calibration of any selected frequency in the sweep range (eg, -3 dB points), resonance point, location of spurious oscillations etc. Refer to paragraph 2-4a for a detailed explanation and operating instructions.

NOTES

Section 2
OPERATING INSTRUCTIONS

2-1. INTRODUCTION

The SERIES 40 function generators are designed to permit normal operation without extensive reference to the manual. However, as with any versatile instrument, the speed of usage and quality of the results can be enhanced by a thorough understanding of the features and constraints of the equipment.

The following material presents the primary features versus model, a description of all controls and indicators, and a discussion of operating hints and applications.

2-2. OPERATING FEATURES

The five models discussed in this manual are the F41, F43, F44, F46, and F47. Table 2-1 indicates the mix of primary features by model numbers. The names and functions of the front and rear panel controls, terminals, and indicators are discussed in figures 2-1 and 2-2.

TABLE 2-1.
PRIMARY FEATURES OF EACH MODEL

	F41	F43	F44	F46	F47
Basic Function Generator	X	X	X	X	X
Step Calibrator	X	X			X
Trigger/Gate		X	X	X	X
Sweep and Marker			X		X
AM				X	

2-3. OPERATING HINTS AND CONSTRAINTS

a. UNIPOLAR RAMPS. - Unipolar positive or negative ramps starting at and returning to zero volts may be triggered from the main generator with the proper settings of the following controls: WAVEFORM at $\overline{\wedge\vee}$ or $\underline{\wedge\vee}$; PHASE at ±90 degrees; MODE at TRIG and the VAR SYM/NORM/.01f switch at VAR SYM. Adjust the VAR SYM vernier for desired duty cycle. OFFSET may be added if desired.

b. UNIPOLAR PULSES. - Either polarity of pulses referenced to ground (or their complements) may be created by setting the WAVEFORM switch at $\overline{\sqcup\!\sqcap}$ or $\underline{\sqcup\!\sqcap}$ and adjusting the PULSE WIDTH vernier. DC offset may be added if desired via the OFFSET control.

c. LIMITATIONS ON MINIMUM PULSE WIDTH. - The pulses created by SERIES 40 generators at rates up to 4 MHz are produced by a constant duty cycle method. The pulse width maintains a constant percentage of the period over many decades of repetition rate. However, as the repetition rate is increased, a conflict develops between the minimum pulse width dictated by rise and fall time considerations and the command to adjust down to 5-percent duty cycle. The rise time limitations prevail and the minimum pulse width on the x1M range is approximately 100 nanoseconds.

At lower repetition rates the minimum pulse width is 5 percent of period (1 microsecond at 50 kHz), and this may impose some operational limitations on the use of the equipment. However, over the F44 and F47 internal sweep ramp generator repetition rate range of approximately 50 kHz 0.01 Hz, very narrow, constant-width pulses (or bursts) may be created by externally connecting the SWEEP RAMP output to the TRIG/SYNC input and triggering (or gating) the main generator to produce pulses of the desired polarity.

d. SWEEP MARKER SUMMING. - It is sometimes convenient to sum the sweep marker d-c voltage step into the same channel with the output signal from the device under test. This is a straightforward task of adding a large resistor in series with the marker output and a shunt resistor across the input to the display. However, if it is undesirable to subject the display to this d-c offset, the operator may ac-couple the marker to the display while observing the location of the marker by the differentiated spike created through careful selection of the R and C values in the coupling network. Most oscilloscopes permit their dual traces to be summed by a switch on the front panel.

e. MINIMIZING SWEEP RETRACE TIME. The F44 and F47 sweep ramp generators utilize a retrace circuit that produces a constant retrace time on any given range. This is independent of the ramp-up time, which is adjustable over a vernier range >200:1. By judicious selection of the operating decade range, the user may create ramp waveforms having retrace times less than 1 percent of period.

f. SWEPT FREQUENCY SLEW RATE LIMITATIONS. - In general, it is possible for the sweep generator (or external VCF signal) to demand a rate of change of frequency from the main generator that is faster than is achievable. Operating the main and sweep generators at their fastest rates while simultaneously asking the sweep width to be "full scale" will result in misleading data because the sweep is neither the starting nor stopping at the frequencies calibrated statically due to voltage slew rate limitations in the frequency control section of the main generator. The user is cautioned to use alternate means (scope) to check the accuracy of the static SWP START and SWP STOP frequency measurements provided by the F44 or F47 whenever operating on the fastest sweep range. This is best done in conjunction with a delayed sweep-type oscilloscope.

g. DELAY VARIATION WITH PULSE WIDTH. - The CDC-type pulse generated by the SERIES 40 creates an inherent variable delay between the SYNC OUT and the pulse output as the PULSE WIDTH control is varied. This delay is a result of "walking" the firing threshold of the Schmitt Trigger pulse width circuit along the leading edge of the triangle waveform to vary the pulse width. In certain applications (see paragraph 2-4) such as two- or four-phase clocks, this feature is extremely convenient.

h. MARKER STEP AVAILABILITY. - Independent of the main generator mode, the TTL-level MKR output step is produced at any time the sweep ramp generator is running (including triggered sweep). This step reverses during the sweep retrace interval and therefore creates a variable-width TTL pulse output that is independent of the sweep sync pulse output and variable with respect to timing between the two leading edges. The width of

TABLE 2-2. REAR PANEL BNC CONNECTORS OF EACH MODEL

MODEL	FUNCTION				
	VCF	FREQ ANA	SWP SYNC	OPTION	OUTPUT
F41	-	-	-	-	-
F43	-	-	-	-	-
F44	X	-	X	-	-
F46	-	-	-	-	-
F47	X	X	X	-	-
OPTION O	-	-	-	-	X

NOTES

this pulse is continuously variable by the SWEEP MARKER vernier or changed in 10 equal steps by the STEP CALIBRATOR switch.

i. OFFSET VERSUS ATTENUATION. - Using the continuously variable OUTPUT LEVEL vernier, the user can vary the a-c signal over a 30-dB (30:1) range without affecting any d-c offset level. However, adjusting the step attenuator also directly affects the offset voltage as well as the waveform.

j. VCF GAIN CONSTANT. - The expected frequency deviation versus VCF input voltage may be calculated when the VCF gain constant (K_V) is known. K_V is a constant on any (linear) range but decreases by 10:1 with each decade range step decrease. For the x1M range K_V is 4 MHz/6 volts = 0.667 MHz/volt nominal.

k. USING THE VAR SYM/NORM/.01f CONTROL. - Three-position switch affects both output frequency and waveforms, as shown in table 2-3.

TABLE 2-3.
VAR SYM/NORM/.01f EFFECTIVITY

Switch Position	VAR SYM/PULSE WIDTH Vernier Active On:	Effect On Output Frequency
VAR SYM	All Waveforms	X0.1
NORM	Pulses Only	X1
.01f	Pulses Only	X0.01

2-4. APPLICATION NOTES

a. FINDING THE SWEEP MARKER FREQUENCY. - First, set up the generator LOG or LIN sweep conditions by adjusting the sweep start and stop frequencies with the CALIB mode (see figure 2-1 (7d)) and selecting the desired sweep time with appropriate retrace duty cycle (see paragraph 2-3e). Second, switch to CONT SWP mode and optimize the display of the signal from the device under test. Third, combine the MKR step with the DUT output display (see paragraph 2-3d) and vary the SWEEP MARKER control until the step transition coincides with an event of interest on the display. Last, switch to CALIB mode and read the marker frequency on a counter. The accuracy of the marker setting when using a scope can be enhanced by magnifying the event of interest with a delayed fast sweep.

b. MAKING OCTAVE STEPS OVER THREE DECADES (F47 ONLY): Using the LOG tuning dial in the CALIB mode, the step calibrator band edges (labeled SWP START and SWP STOP) are adjusted to be exactly three decades apart in frequency. Then advancing through the points of the STEP CALIBRATOR produces exactly 10 octave steps (because there are 3 1/3 octaves per decade).

c. CENTERING THE STEP CALIBRATOR BAND ON A FREQUENCY OF INTEREST. - To place the center frequency of the STEP CALBRATOR (step 5) on a known frequency of interest, first establish the CALIB mode and while dwelling at step 0, set the frequency dial to the desired low-band edge using a counter. Then move to step 5 and adjust the calibrator limit cursor until the desired center frequency is read on the counter. The frequency of interest is now centered exactly between the band edges, and the band is divided into 10 equal increments for response plotting.

d. TWO-PHASE CLOCK GENERATION. When the pulse waveform is selected and the pulse is adjusted to have a 50-percent duty cycle, then the square waves at the main OUTPUT and the SYNC OUT are 90 degrees out

of phase with each other. This relationship is independent of frequency. Appropriate gating and/or dividing will produce four independent clock lines with a 90 degree relationship. The synchronization feature of the SERIES 40 can be used here (paragraph 2-2) if frequency accuracy is important, and the ability of the SERIES 40 to synchronize to harmonics and subharmonics can be used to operate at frequencies other than those for which precision standards are directly available.

e. CREATING NARROW PULSES WITH LONG VARIABLE DELAYS. - The sweep ramp generator oscillates at frequencies from 50 kHz to less than 0.01 Hz. Either the MKR output pulse or the SWEEP SYNC pulse may be used as the clock reference. By cabling the SWEEP RAMP output to the TRIG/SYNC input, operating in the TRIG mode and adjusting the TRIGGER LEVEL control to pick off the desired delay along the ramp, the main generator will trigger out one pulse each ramp period.

f. USING THE STEP CALIBRATOR AS A SWEEP MARKER (F47 ONLY). - Whenever the sweep ramp generator is running, the timing of the MKR step may be controlled by the STEP CALIBRATOR as well as the SWEEP MARKER vernier (see paragraph 2-3h). Thus, the marker step can be made to occur at any of the 11 calibrated points and serve as a visual aid to estimating the frequency of an event of interest without the use of a counter. This feature is extremely convenient in LOG sweep if the operator first lists the frequencies occurring at each step.

g. FREQUENCY RESPONSE PLOTS AND CRT DISPLAYS. - Frequency response plots and CRT displays of filters, amplifiers, networks and other devices may be made using the OUTPUT to drive the device under test and either the FREQ ANA log or SWEEP RAMP outputs to drive the X axis of the plotter or scope.

Of particular interest are logarithmically swept X-Y plots made using semi-log paper. In this case the SWEEP RAMP BNC provides a 0 to 6V linear ramp output which is independent of FREQ DIAL and SWP LIMIT settings. (See section 3-10a for LOG use information.)

Manual sweeping may be accomplished using the SWEEP MKR vernier in the CALIB mode. This facilitates plotter or scope setup.

Section 3
CIRCUIT DESCRIPTION

3-1. INTRODUCTION

The simplified block diagram (figure 3-1) shows the major functional blocks of the system. For more detailed reference, see the circuit schematic at the back of the manual.

3-2. POWER SUPPLY

a. UNREGULATED DC VOLTAGE AND RECTIFIERS. - Two unregulated d-c voltages (+30 volts and -30 volts nominal) are generated to supply the output amplifier directly and to supply power to the regulator circuits that serve the balance of the instruments. One tapped-secondary transformer winding serves two full wave rectifiers.

b. REGULATED SUPPLIES. - From the two unregulated supply voltages (±30 volts nominal) four additional voltages are derived to provide ±15 volts and ±5 volts. The +15 volt supply is used as a reference for the other regulated supplies.

NOTE

If the +15 volt supply is inoperative, all other supplies are also inoperative.

The regulated supplies consist mainly of a pass transistor and a regulator. Each regulator output follows any change in the current requirements through the pass transistor and thus maintains a constant voltage. The positive supplies are referenced to a Zener diode, and the negative supplies track the positive supplies.

3-3. MAIN GENERATOR

The main generator comprises a diode bridge, plus and minus current source, a voltage-level sensor (VLS), and a triangle amplifier arranged in a closed loop. The basic loop concept consists of generating a voltage proportional to the desired frequency and converting this level to a constant current used to charge a capacitor. At some defined positive-voltage level across the capacitor, the VLS operates on the diode bridge to cause an equal and opposite current to be applied to the integrating capacitor. When an equal negative-voltage level is detected, the process is repeated.

The function of the VLS is to select either a positive- or negative-current source, which, in turn, charges the appropriate range capacitor to a value that causes the VLS to switch the current source and reverse the direction of the ramp. The output from the capacitor is then buffered by the triangle amplifier to drive the circuits using the triangle. The square wave output of the VLS is buffered and made available on the front panel as the sync output. Either the triangle or square wave from the main generator may be selected at the wave-

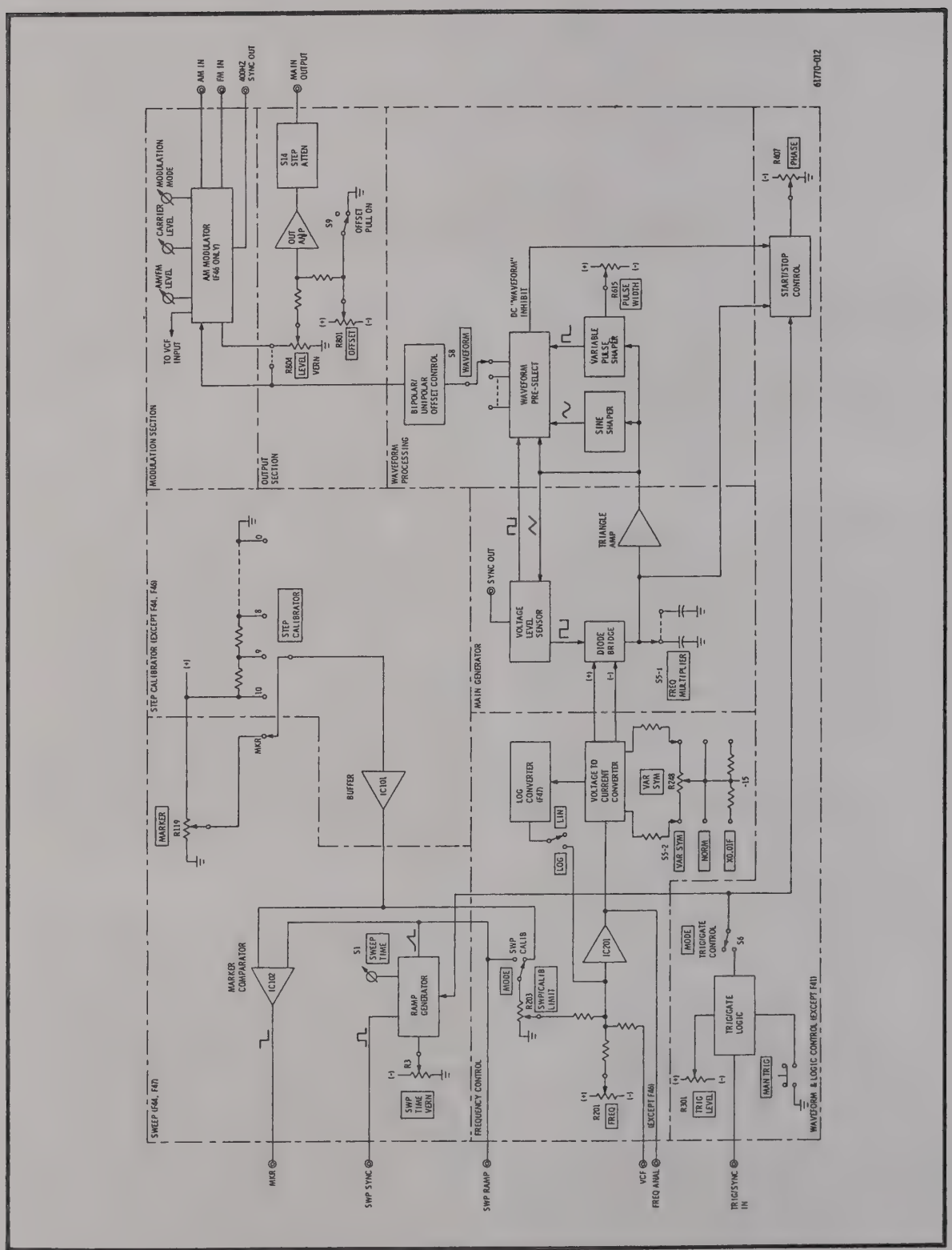


Figure 3-1. Simplified Block Diagram

form switch and made available at the main output through the output amplifier and step attenuator.

3-4. WAVEFORM PROCESSING

The sine wave is derived by shaping and amplifying the triangle, using shunt-diode-resistor networks. The width of the pulse waveform is also derived from the triangle by adjusting the firing point of a Schmitt trigger in the variable pulse shaper along the voltage excursion of the constant-amplitude triangle. The resulting rectangular waveform provides a constant duty cycle (versus frequency) pulse at the same repetition rate as the triangle. The two derived waveforms, plus the triangle and square wave from the main generator, are available at the front panel.

3-5. OUTPUT SECTION

The output section consists of the output amplifier with its associated level and offset controls plus the step attenuator. The output amplifier has a differential structure which provides high common mode rejection and permits the use of unregulated power supplies with very small 120 Hz ripple component. (Unregulated supplies are used rather than dissipate large amounts of pass transistor power supplying 40V p-p into the 100 Ω load that the output amplifier sees.) The complementary emitter follower (CEF) output provides the low output impedance and low crossover distortion required in a broadband dc coupled signal source. The quad transistor driver stage operates class A and has been optimized to pass both sine and square waves.

CAUTION

The output amplifier has been designed to sustain short circuits for extended periods of time without permanent damage, however, certain voltage sources applied to the OUTPUT BNC, even momentarily, may damage the output section.

The step attenuator provides up to 60 dB of attenuation in 20-dB increments with a 30-dB vernier to allow for an overall attenuation up to 90 dB.

3-6. FREQUENCY CONTROL

A single operational amplifier (IC201) is used to generate a voltage representing the summation of all frequency commands: (1) voltage derived from the frequency control (R201), (2) voltages present on the VCF input connector, and (3) any sweep/calibrator voltage appearing at the wiper of the sweep/calibrator limit control (R203). The voltage at the collector of Q3 is the voltage analog of frequency. This voltage drives the negative current source (IC2-3) and a current mirror composed of IC2-9, Q8, Q7 and IC2-12 which drives the positive current source (IC2-15).

The setting of R248 controls the ratio of currents in the negative current source and the current mirror such that the triangle waveform is varied in time symmetry from 5 percent to 95 percent ratio (1:19) of normal.

3-7. WAVEFORM AND LOGIC CONTROL

The waveform and logic control circuitry consists of trig/gate logic, start/stop control logic, and the associated switches and controls. These circuits determine whether the generator produces a single-cycle output, a multiple-cycle burst, or a continuous wave train. In the trigger mode, the start/stop circuit holds the generator off by clamping the input to the triangle amplifier. When the trigger signal is

received by the generator, it is applied to a gate that allows the generator to run for one complete cycle. In the gate mode, the generator continues to oscillate for as long as the gate signal is present at the trigger input, allowing multiple-cycle bursts.

3-8. SWEEP CONTROL

The sweep control circuitry consists of a ramp generator, marker comparator, and the associated controls. The sweep control circuits generate a ramp that is applied to the input of the frequency control circuitry. The duration of this ramp (sweep time) is determined by a range capacitor in the feedback of the sweep ramp generator. This internal ramp is also brought to the front panel as an auxiliary generator output.

The marker comparator is a digital output comparator (TTL-level step) with the sweep ramp applied to one input and a buffered marker voltage (unloaded) applied to the other side. The TTL-level step occurs when the sweep ramp and marker voltage are in coincidence.

3-9. STEP CALIBRATOR

The step calibrator consists of a rotary switch and a precision voltage divider. As the switch is rotated through each position, a precision voltage is fed to the frequency control circuits and is summed with the signal from the frequency control. Thus each step causes a voltage increment to be added to or subtracted from the frequency voltage, causing the output frequency to step to the corresponding frequency.

3-10. LOG CONVERTER

Logarithmic control of frequency is implemented in a fashion such that four decades of frequency ratio each equally occupy the frequency dial.

The log converter is placed in the feedback path of the linear loop around IC201A when the F47 LOG-LIN switch is placed in LOG. Feedback current from IC2-6 is drawn through Q202B collector producing a logarithmic voltage at Q202B base. This voltage is maintained by a minor feedback loop (Q202A, Q201) which holds the base emitter voltage of Q202B at sufficient bias to supply the demand of the feedback current. Temperature compensation is implemented by use of the matched transistor in Q202.

The logarithmic voltage generated at Q201 source determines the ultimate feedback to IC201A.

a. LOG SWEEP USE. - In general when using the log feature of the F47 in sweeping applications it is recommended that the generator be swept no faster than about 1/10 the lowest or start frequency chosen in order to obtain reasonable FM results. Table 3-1 shows recommended maximum sweep rates versus swept minimum frequency.

3-11. MODULATION (F46 ONLY)

The F46 modulation section is included elsewhere in this manual.

TABLE 3-1. RECOMMENDED LOG SWEEP RATES

Sweep Generator (Max Sweep Rate)		Function Generator (Start Frequency)		
SWP TIME	SWP VERN	FREQ DIAL	FREQ MULT	f-START
10 ms	MIDSCALE	.0004	X1M	400 Hz
1 ms	MIDSCALE	.004	X1M	4 KHz
10 ms	MIDSCALE	.04	X1M	40 KHz
100 ms	MIDSCALE	.0004	X100K	40 Hz
10 ms	MIDSCALE	.004	X100K	400 Hz
1 ms	MIDSCALE	.04	X100K	4 KHz
1 s	MIDSCALE	.0004	X10K	4 Hz

NOTES

Section 4
CALIBRATION

4-1. INTRODUCTION

This section contains the necessary equipment list and the detailed procedures for calibrating all elements of the Series 40 instrument. Table 4-1 presents a recommended list of test equipment and table 4-2 provides the recommended sequence and methods. Figure 4-1 is an Adjustment Location Diagram and Test Point Location Diagram.

TABLE 4-1. TEST EQUIPMENT REQUIRED

Test Equipment	Suggested Model	General Requirements For Calibration
Digital Voltmeter	John Fluke 8300A*	DC: 1-mv resolution up to 15.0 vdc. AC: Average reading 1-mv resolution up to 20 vac.
Counter	HP 5326A	FREQ: 5-digit resolution up to 5 MHz. PERIOD: 200 sec with 0.1-sec resolution. TIME INTERVAL:
RF Voltmeter (OK 50mHz SCOPE)	Boontoon 91C, D, or HP 3406	50-MHz bandwidth and 0.1-dB resolution.
Oscilloscope	Tektronix 453, 454 or 585	50 MHz bandwidth. 0.1 v/cm vertical sensitivity.
Function Generator or Oscillator	IEC F31-F34 or IEC F51-F55	10v p-p sinewave into 50 ohms.
Distortion Analyzer	HP 333A or HP 334A	FREQ RANGE: 5 Hz to 600 kHz. Distortion introduced by instrument: <0.03 percent from 5 Hz to 200 kHz. <0.06 percent from 200 to 600 kHz.

* (Will measure DC in presence of AC)

TABLE 4-2. CALIBRATION PROCEDURE

STEP	CALIBRATION	SETTINGS OF CONTROLS	TEST EQUIPMENT (MODE)	PROCEDURE
1.0	POWER SUPPLY	For 115 VAC applied line voltage: Voltage Selectors @ NORM, 115 VAC Power Switch ON OR For 230 VAC applied line voltage: Voltage Selectors @ NORM, 230 VAC Momentarily set Voltage Selector @ Low	DVM (DC)	1. Adjust R909 for 15.00 ±0.01 VDC @ TP903 2. Measure: -14.9 to 15.1 VDC @ TP904 +4.75 to +5.25 VDC @ TP906 -4.75 to -5.25 VDC @ TP905 +28.0 to +32.0 VDC @ TP901 -28.0 to -32.0 VDC @ TP902 3. Measure -32.0 to -36.0 VDC @ TP902
2.0	TRIANGLE GENERATION LOOP			
2.1	Triangle amplifier zero adjust	FREQ DIAL @4 FREQ MULT @ X1K, NORM	DVM (DC)	Adjust R418 for 0.00 ±0.05 VDC @ TP401
2.2	Triangle amplitude symmetry adjust	MODE @ CONT WAVEFORM @ SYNC OUT @ CARRIER (F46)		Adjust R512 for 0.00 ±0.001 VDC ± TP403
2.3	Triangle amplitude adjust	MODULATION OFF LOG/LIN @ LIN (F47)	DVM (AC)	Adjust R509 for 1.667 ±0.002 VAC @ TP403 (6V p-p triangle waveform produces a correlated value of 1.667 VAC on an average reading DVM)

Table 4-2. Calibration Procedure (Continued)

STEP	CALIBRATION	SETTINGS OF CONTROLS	TEST EQUIPMENT (MODE)	PROCEDURE
3.0	STEP CALIBRATOR (F41 ONLY)			
3.1	CAL/MKR ZERO adjust	MODE @ NORM	DVM (DC)	1. Adjust R111 for 0.000 ±0.002 VDC @ TP101.
	CAL/MKR GAIN adjust	MODE @ 10		2. Adjust R115 for 6.000 ±0.002 VDC @ TP101.
		MODE @ 0		3. Measure 0.000 ±0.002 VDC @ TP101.
4.0	FREQUENCY			
4.1	Linear high frequency adjust	FREQ DIAL @4 FREQ MULT @ X10K, NORM	COUNTER (Freq)	Adjust R253 for 40.0 ±0.4 kHz @ SYNC OUT BNC.
4.2	Low symmetry adjust	FREQ DIAL @ 0.1 (last mark on dial)	COUNTER (time interval, - to + slope)	1. Measure - to + slope times interval (Channel A to Channel B).
			COUNTER (time interval, + to - slope)	2. Adjust R229 for + to - slope, time interval equal to that of procedure 1, ±0.2 microseconds.
		FREQ DIAL @ CW		3. Measure time interval greater than 25 milliseconds.

Table 4-2. Calibration Procedure (Continued)

STEP	CALIBRATION	SETTINGS OF CONTROLS	TEST EQUIPMENT (MODE)	PROCEDURE
11.0	CALIBRATOR (F41/F43 ONLY)			
11.1	Calibrator zero adjust	STEP CALIBRATOR @ NORM/OFF (F41/F43) MODE @ CALIB (F43)	DVM (DC)	Adjust R111 for 0.000 ±0.002 VDC @ TP101.
11.2	Calibrator gain adjust	STEP CALIBRATOR @ 10		1. Adjust R115 for 6.000 ±0.002 VDC @ TP101.
		STEP CAL @ 0		2. Read same value as in procedure 1.
12.0	SWEEP MKR (F44 ONLY)			
12.1	Calibrator zero adjust	MODE @ CALIB SWEEP MARKER @ SWP START	DVM (DC)	Adjust R111 for 0.000 ±0.002 VDC ± TP101.
12.2	Calibrator gain adjust	SWEEP MARKER @ SWP STOP		Adjust R115 for 6.000 ±0.002 VDC @ TP101.
13.0	STEP CALIBRATOR/ SWEEP MARKER (F47)	Same as step 3 for F41		
13.1	Calibrator zero adjust	MODE @ CALIB STEP CALIBRATOR @ SWP START	DVM (DC)	Adjust R111 for 0.00 ±0.002 VDC @ TP101.
13.2	Calibrator gain adjust	STEP CALIBRATOR @ SWP STOP		Adjust R115 for 6.000 ±0.002 VDC @ TP101.

Table 4-2. Calibration Procedure (Continued)

STEP	CALIBRATION	SETTINGS OF CONTROLS	TEST EQUIPMENT (MODE)	PROCEDURE
13.3	Sweep marker overrange	STEP CALIBRATOR @ MKR SWEEP MKR @ CCW STOP	DVM (DC)	1. Measure -0.1 to -0.5 VDC @ TP101.
		SWEEP MKR @ CW STOP		2. Measure 6.0 to 6.5 VDC @ TP101.
14.0	SWEEP/ CALIBRATOR LIMIT (EXCEPT F46)			
	Zero adjust	FREQ DIAL @ .4 FREQ MULT @ X10K NORM MODE @ CONT	COUNTER (FREQ)	1. Note frequency on counter.
		MODE @ CAL SWEEP/CAL LIMIT @ CCW STOP		2. Switch between NORM and 10 (F41); or 0 and 10 F43) or SWP START and SWP STOP (F47) and adjust R209 until no difference in frequency is noted. The null frequency shall be within 2 percent of the value noted in procedure 1.
	High limit adjust	SWEEP CAL LIM @ 4 on dial		3. Adjust R212 for 40.0 ±0.1 kHz.
				End of calibration for F41 and F43.

Table 4-2. Calibration Procedure (Continued)

STEP	CALIBRATION	SETTINGS OF CONTROLS	TEST EQUIPMENT (MODE)	PROCEDURE
15.0	SWEEP (F44, F47 ONLY)			
15.1	Ramp amplitude adjust	MODE @ CONT SWP SWP TIME @ 1 ms SWP VERNIER @ CW WAVEFORM @ DC	DVM (AC)	Adjust R033 for 1.667 ±0.001 VAC @ SWEEP RAMP BNC without 600 ohm load. (6V p-p sawtooth waveform produces a correlated value of 1.667 VAC on average reading DVM)
15.2	Ramp zero adjust		DVM (DC) Note: See Table 4-1 (*)	Adjust R029 for 3.00 ±0.005 VDC at SWEEP RAMP BNC.
15.3	Ramp amplitude and zero adjust			Repeat steps 15.1 and 15.2 as required.
15.4	Cal sweep time adjust	SWP VERNIER @ CW	COUNTER (time interval - to +)	Adjust R004 for 970 ±10 microseconds.
15.5	Long sweep time adjust	MODE @ TRIG SWP VERNIER @ CCW		Adjust R019 for -5 ±2.0 MVDC. SYNC OUT BNC with no termination. (End of Calibration for F44 and F47.)

NOTE: Refer to the Addendum for the continuation of calibration procedures for the Model F46 Function Generator.

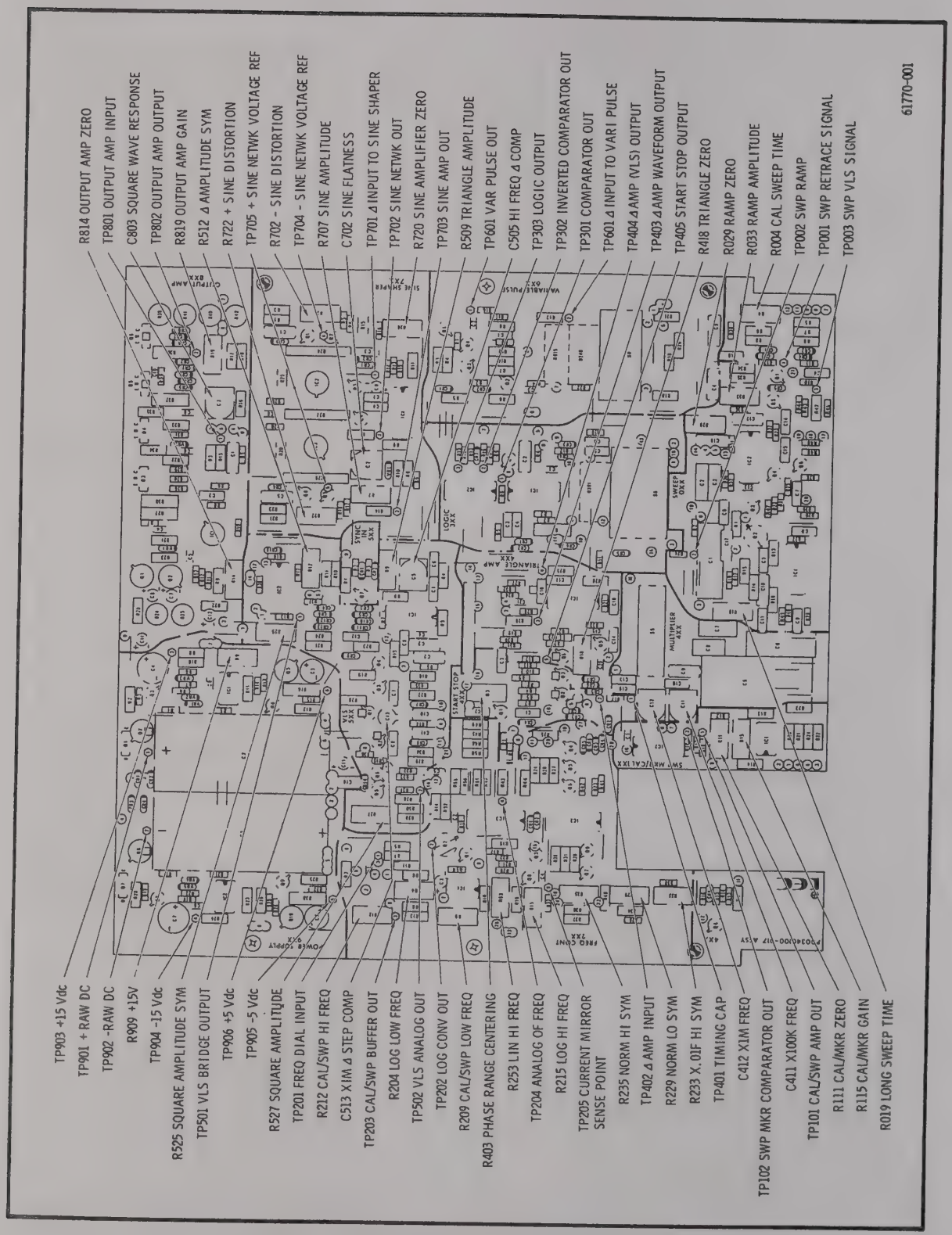


Figure 4-1. Component Adjustment and Test Point Diagram

Section 5
MAINTENANCE

5-1. INTRODUCTION

This section of your SERIES 40 manual was prepared with service personnel in mind. Accordingly, the schematic diagram at the back of the manual provides waveform information at critical points in the instrument to aid in diagnosing instrument failures. Figures 5-1 through 5-4 are switch assembly diagrams, and the Troubleshooting Guide (table 5-1) provides detailed information for a number of possible malfunctions. Logic and Stop-Start timing diagrams are shown in figures 5-5 and 5-6.

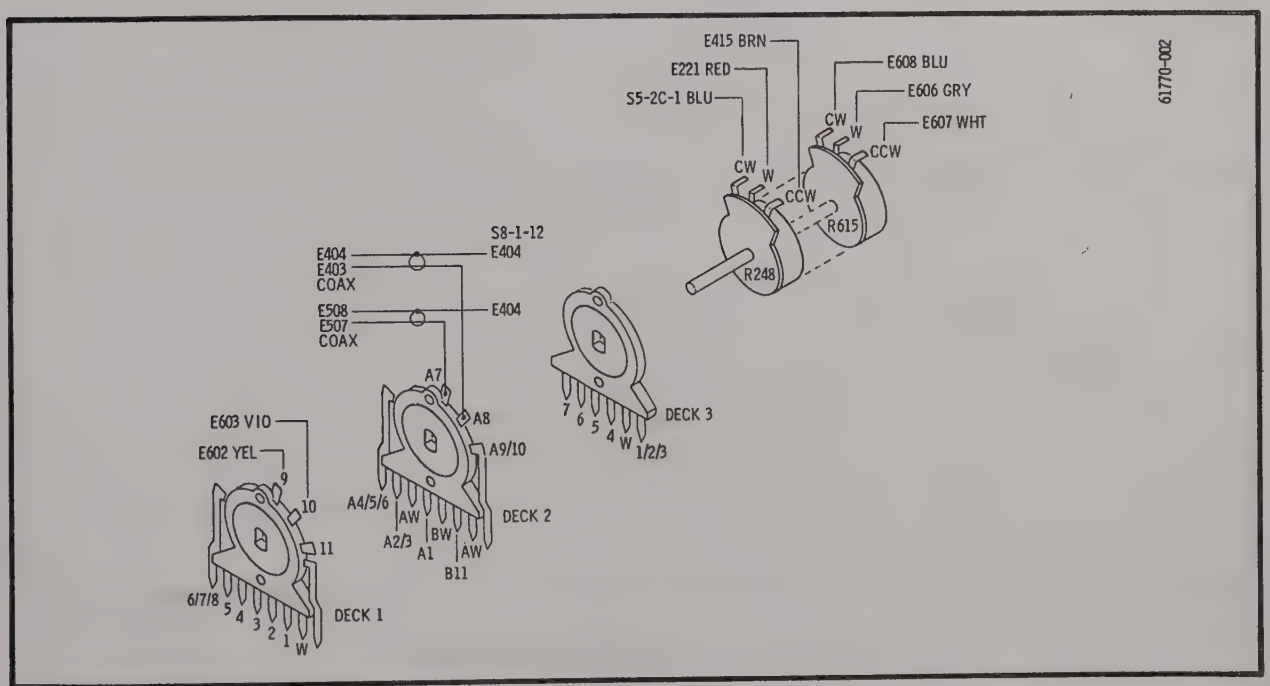


Figure 5-1. Waveform Switch (S8) with VAR SYM (R248) and VAR Pulse (R615) Potentiometers

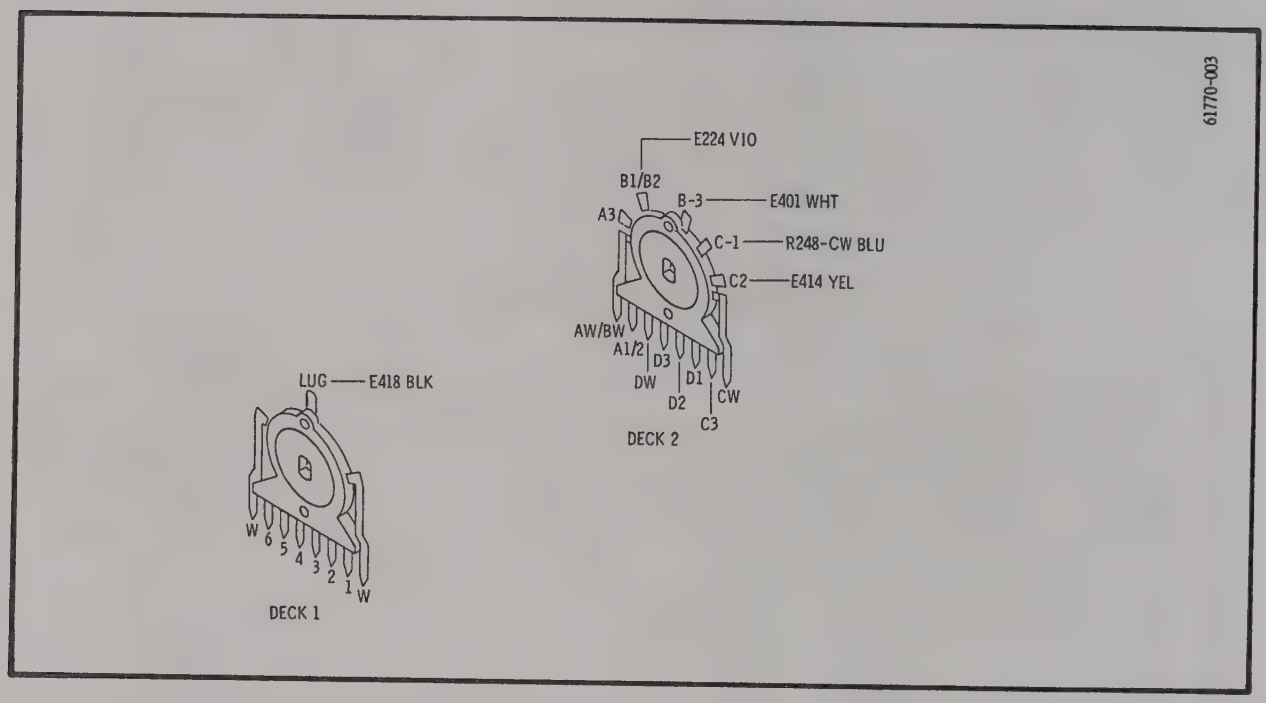


Figure 5-2. Multiplier Switch (S5)

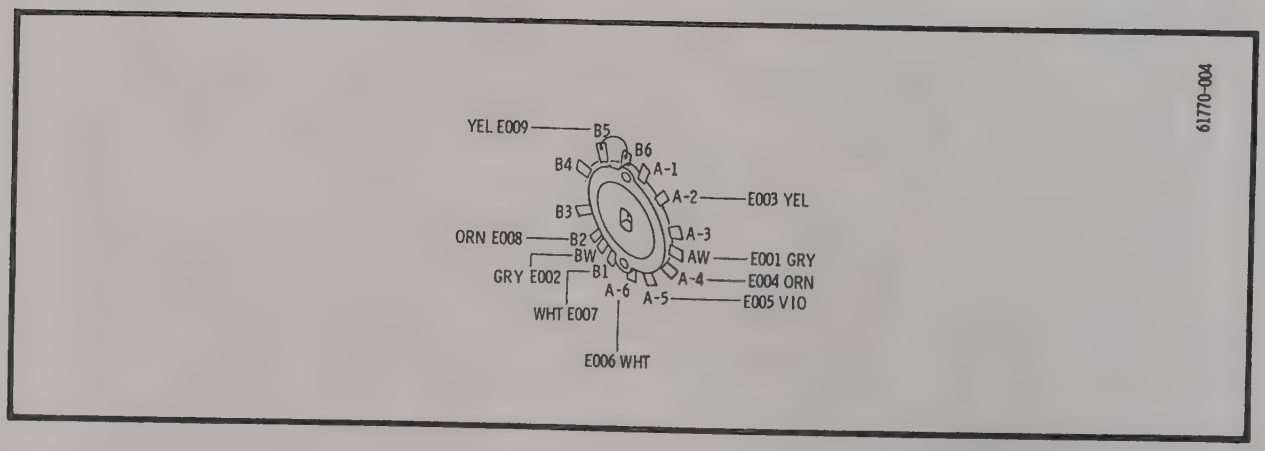


Figure 5-3. Sweep Time Switch (S1)

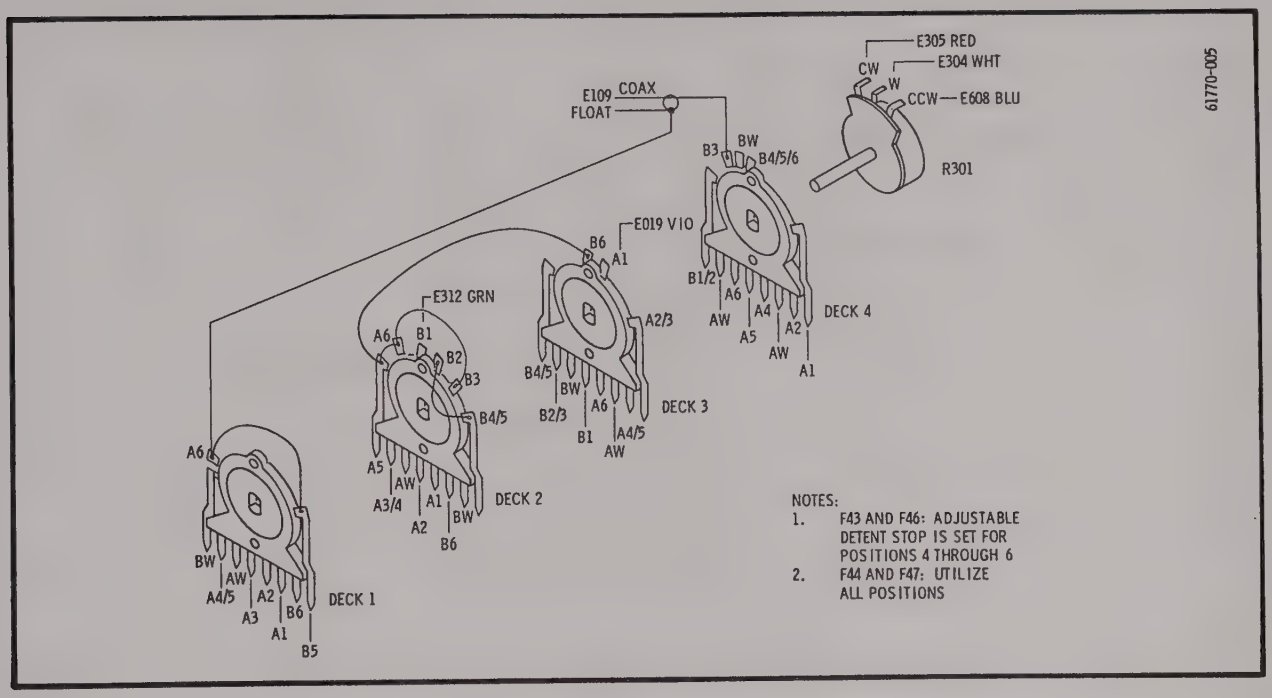


Figure 5-4. Mode Switch (S6) and Trigger Level (R301) Potentiometers

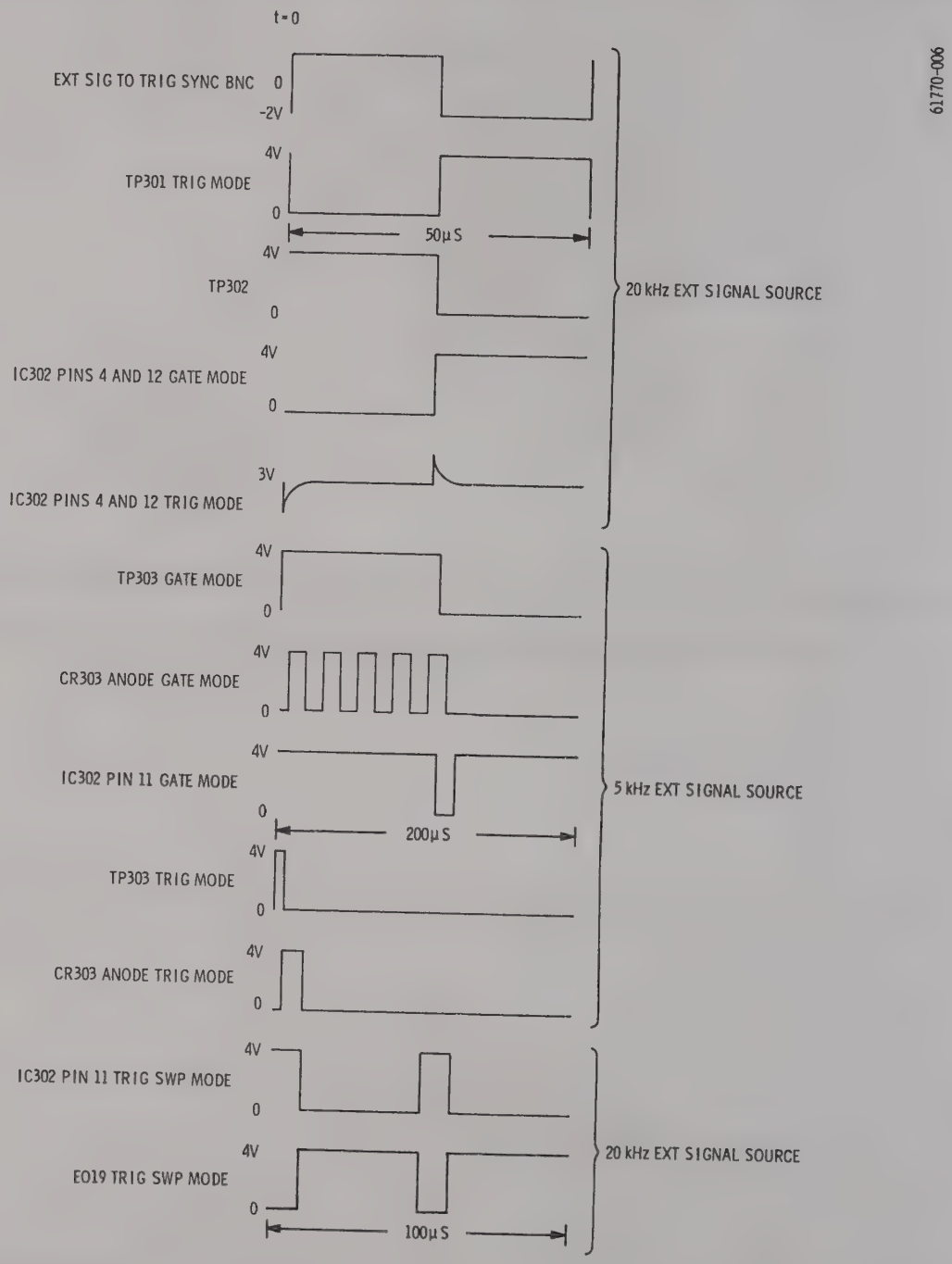


Figure 5-5. Logic Section Timing Diagrams

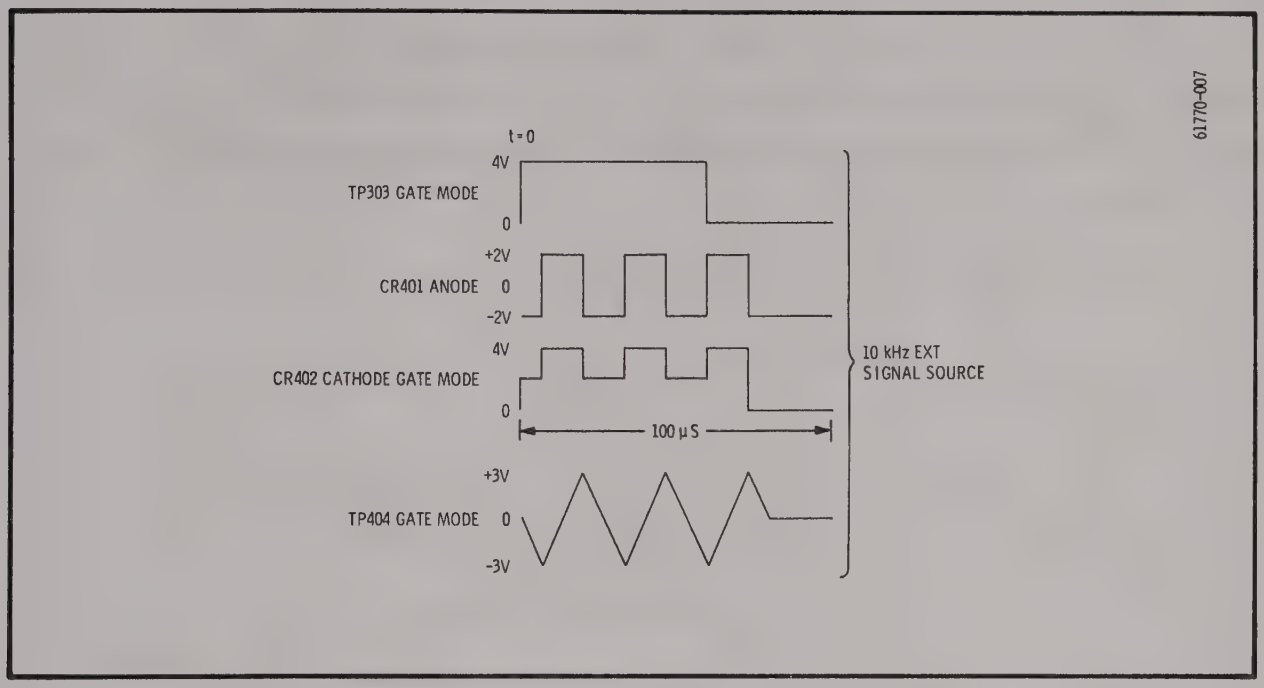


Figure 5-6. Stop/Start Section Timing Diagrams

TIMING DIAGRAM
GENERAL TEST CONDITIONS

GENERATOR UNDER TEST:
- Freq Dial @ ≈ 4
- FREQUENCY MULTIPLIER @ X10K, NORM
- TRIGGER LEVEL @ MIDSCALE
- SWEEP TIME @ 10 µs
- SWEEP VERNIER for 10 µs
- PHASE @ MIDSCALE

EXTERNAL SIGNAL SOURCE:
- Frequency as indicated
- Square wave
- 4V PP

OSCILLOSCOPE:
- Vertical as indicated
- Horizontal as indicated
- Triggering
  - + LEVEL, AC coupling
  - + SLOPE, Ext trigger source

CONNECTIONS:
- External signal source
- Output to scope
- External trigger BNC

TABLE 5-1. TROUBLESHOOTING GUIDE

Symptom	Possible Cause	Remarks
1. No OUTPUT:		
a. Power Lamp Off	1. Fuse blown 2. Line switches in wrong position	See Section 1-5
b. For all MODE positions	1. Logic section faulty 2. Stop/Start section faulty	See part 23 See part 24
c. For TRIG GATE and TRIG SWP modes	1. TRIGGER LEVEL potentiometer not adjusted for input signal or no signal input to TRIGGER SYNC BNC 2. PHASE potentiometer set to one extreme 3. Logic section faulty (F44, F46, F47)	 See part 23
d. For all waveform positions, MODE switch in CONT	1. Output amplifier disabled 2. Power supply disabled	See part 17 See part 21
e. For all waveform positions except DC (OFFSET works)	1. MODE switch in GATE, TRIG or TRIG SWP without trigger input 2. Triangle loop stalled 3. Logic or STOP/START section faulty (F44, F46, F47)	 See part 18 See part 23/24
f. Sine waveform only has no output	Sine shaper disabled	See step 22
g. Square waveform only has no output but SYNC OUT present	1. Open COAX between E507 and Waveform switch, S8 2. Short to ground between CR511 cathode and Q507 or Q508 bases 3. Open CR511 or CR513, R523, R524, R525, R526, R529, R530, Q505, R531, R532, R533, R534, Q506	

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
h. No offset capability	1. Open wire from R801/S9, OFFSET control to E801, E802 or E803 2. S9, OFFSET control not functioning (always closed) 3. Open R803 or R802 on OFFSET control	
i. Variable Pulse waveform only has no output	1. Variable Pulse circuit disabled 2. Open wire from R615 VAR PULSE potentiometer to E607, E606, or E608	See part 25
2. No SYNC OUT		
a. OV OUT (logic 0)	1. IC502 faulty 2. Open wire between E505/E506 and SYNC OUT BNC 3. Shorted R518	
b. Output always positive	IC502 faulty	See part 21
3. No SWEEP RAMP		
a. No SWEEP SYNC	1. SWEEP TIME switch turned off 2. MODE in TRIG SWP position 3. Sweep Generator faulty	See part 14
b. SWEEP SYNC is O.K.	1. Open wire from E013 to SWP RAMP BNC 2. Open R038 or shorted C016	
4. No SWEEP SYNC but SWP RAMP is O.K.	1. Open wire between E017/E018 and SWEEP SYNC BNC 2. Shorted R046 3. Open R045 4. Q006 and/or R044 faulty	

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
5. No MKR OUT		
a. OV OUT (logic 0)	1. Calibrator section disabled 2. IC502 faulty 3. Open wire between E515/E514 and MKR OUT BNC 4. IC102 faulty	See part 26
b. 3V OUT (logic 1)	1. No sweep input, Sweep Generator disabled 2. Open wire between E107 and E513 3. IC102 stuck at logic 1, above 1.5V	See part 14
6. No FREQ ANALOG OUT		
a. Frequency varies in accordance with dial	1. Open wire between E210 and FREQ ANAL BNC or S2 toggle switch (F44) 2. R225 shorted 3. Q204 faulty 4. R224 open	
b. Frequency does not vary with dial	Frequency Control Circuit section disabled	See part 19
7. Improper OUTPUT LEVEL		
a. Low amplitude	1. Output amplifier faulty 2. Misadjusted R819 3. Failure in attenuator assembly 4. Failure in LEVEL potentiometer (R804)	See part 17 Check attenuator calibration
b. Large d-c offsets	1. Output amplifier faulty 2. S9 OFFSET switch does not close	See part 17

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
8. Improper OUTPUT WAVE FORMS		
a. Waveforms not time symmetrical		
(1) At all dial frequencies for all waveforms except Pulse and DC	1. Switch in VAR SYM position 2. R235, (for NORM) or R233 (for X.01f) misadjusted 3. Frequency Control section, (positive current loop) faulty.	See part 19
(2) At low dial frequencies for all waveforms except Pulse and DC	1. R229 misadjusted 2. Frequency control section faulty 3. Leaky C405, C406, C407, or C408 4. Leaky CR406 or CR407 (F41 only) 5. Leaky CR203, CR204, CR205, CR206	See part 19
b. Waveforms Offset		
(1) , waveforms all offset in same direction.	1. R814 misadjusted 2. Output amplifier faulty	See part 17
(2) and offset in opposite directions	R512 misadjusted	
(3) offset	R525 misadjusted	
(4) unipolar	1. Q506 open if output positive going 2. Q506 open if output negative going	
c. All waveforms clipped	Output amplifier faulty	See part 17

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
d. Nonlinear triangle		
(1) For all FREQ MULT positions	Leaky diodes: CR203, C205, CR204, or CR206	
(2) For specific FREQ MULT positions	Leaky capacitors: C405, C406, C407 or C408	
e. Excessive overshoot or ringing on squarewave	1. C803 misadjusted 2. Output amplifier faulty	 See part 17
f. Excessive sine distortion	1. Sine shaper calibration 2. Sine shaper faulty	See Calibration Procedure See part 22
g. AM or FM on output		
(1) Independent of SWEEP	(1) Power supply ripple excessive (2) Frequency control section, oscillations	See part 21 See part 19
(2) Sweep related	Misadjusted R203	See Calibration Procedure
9. Improper FREQUENCY CALIBRATION		
a. Large frequency error in specific FREQ MULT position	1. VAR-SYM/NORM/X.01f switch in wrong position 2. C405 through C414 faulty 3. MULT switch S5-1 contact open	
b. Large frequency error in all FREQ MULT positions	1. LOG/LIN switch in LOG (47) 2. Frequency control section out of calibration or faulty 3. VLS section out of calibration or faulty 4. Q405 faulty	 See part 19 See part 18

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
c. Frequency does not change with dial	Frequency control section faulty	See part 19
10. Insufficient FREQ RANGE		
< 1000: 1 VCG or	1. Misadjustment of R205 and R1	
< 1000: 1 SWEEP or	2. Frequency control section faulty	See part 19
< 1000: 1 DIAL	3. Misadjustment of R205 or tuning assembly out of mechanical alignment	Consult factory
11. GATE MODE Faults		
a. No dynamic gating	1. TRIGGER LEVEL potentiometer R301 open circuit to ±15V, E305 or E608.	
	2. Open wire from TRIG/SYNC BNC to S6-1A (Mode) via E301/E302 coax	
	3. MAN TRIG switch, open 1 to 2	
	4. S6-1A or S6-4A switch decks open	See timing diagrams, section
	5. Logic section faulty	See part 23
	6. Start/Stop section faulty	See part 24
b. No manual gating	1. MAN TRIG switch faulty	
	2. S6-4A open	
c. Incomplete last cycle	1. S6-3B open	
	2. Logic section faulty	See part 23
	3. Start/Stop section faulty	See part 24
		See timing diagrams, section

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
d. Baseline oscillation	Start/Stop section faulty	See step 24
12. TRIGGER MODE Faults		
a. More than one cycle produced or incomplete cycle produced	1. Start/Stop section faulty 2. Logic section faulty	See part 24 See part 23 See timing diagrams, section
b. No dynamic triggering	1. TRIG LEVEL potentiometer R301 open circuit to ±15V, E305 or E608 2. Open wire from TRIG/SYNC BNC to S6-1A (Mode) via E301/E302 coax 3. MAN TRIG switch open 1 to 2 4. S6-1A or S6-4A switch wafers open 5. Logic section faulty 6. Start/Stop section faulty	 See timing diagrams section See part 23 See part 24
c. No manual triggering	1. MAN TRIG switch faulty 2. S6-4A open	
d. Baseline oscillations	Start/Stop section faulty	See part 24
13. CALIB MODE Faults		
a. Frequency at O position of STEP CALIBRATOR not same as frequency in CONT mode	1. R111 misadjusted 2. IC101 faculity 3. Open wire from STEP CAL switch to E101 or E102	See Calibration Procedure

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
b. Frequency at 10 position of STEP CAL not same as frequency of CAL LIM in CONT mode	1. R212 or R115 misadjusted 2. IC101 faulty	See Calibration Procedure
c. Frequencies of all steps between O and 10 not the same when dial and CAL LIM coincident at 4 on dial	R209 misadjusted	See Calibration Procedure
14. SWEEP GENERATOR Faults		
a. SWP RAMP output at O; No SWP SYNC	1. Mode switch set at TRIG SWP 2. Q003 shorted; Q004 open 3. Wire from E020 to E314 open 4. Logic section faulty	See part 23
b. SWP RAMP output greater than 6V positive; no SWP SYNC	1. IC002 faulty (pin 9 does not go to 3V state) 2. Q002 or Q001 open 3. CR001, CR002 or CR003 open	
c. SWP RAMP output more negative than 0V, no SWP SYNC	1. IC002 faulty, pin 9 does not go to 0V state. 2. Q002 or Q001 shorted	
d. SWP RAMP OUTPUT stalled between 0V and 6V	1. Q002 or Q003 leaky 2. R019 misadjusted	See Calibration Procedure
e. No SWP RAMP but SWP SYNC O.K.		See part 3b

Table 5-1. Troubleshooting Guide (Continued)

Sympton	Possible Cause	Remarks
f. No SWP SYNC but SWP RAMP O.K.		See part 4
g. Vernier has less than 100:1 sweep time range	R019 misadjusted	See Calibration Procedure
h. Ramp non-linear	Leaky Q001, QA002, Q003 CR001, CR002, or CR003	
15. CONT SWP MODE Faults		
a. SWP RAMP and SWP SYNC Outputs O.K. but main output doesn't sweep	1. SWP/CAL LIM dial at CCW stop 2. IC201B output amplifier faulty 3. Wire from SWEEP/CAL LIM potentiometer wiper to E207 open 4. Twisted pair from S6-4B to SWEEP/CAL LIM potentiometer open 5. S6-4B switch open 6. R211 or R212 open	
b. No sweep ramp	Sweep generator faulty	See part 14
16. TRIGGERED SWP Faults		
a. No triggered sweep, external or manual	1. R019 misadjusted 2. Logic section faulty	See Calibration Procedure See timing diagrams, section
	3. Sweep generator faulty 4. Open wire from S6-2B position 1 to E312	See part 14

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
17. OUTPUT AMP Faults		
a. Excessive square wave overshoot	1. No termination at the end of coax cable 2. C903 misadjusted 3. Open or faulty capacitor: C904, C905, C908 or C909	
b. Waveforms clipped	Open feedback network: R819, R817 or R16 open; R818 shorted	
c. No output at TP902	1. No input at TP1 2. Open jumper wires carrying raw voltage	Check bias voltages shown on schematic; refer to part 17j
d. Output at TP902 at +20V or more	Q905 faulty	
e. Output at TP902 at -20V or more	Q906 faulty	
f. Rise/fall times excessive	Q905 or Q906 open	
g. Waveforms distorted under load	Q905 or Q906 open	
h. Voltages at Q901 and Q903 bases do not compare		

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
(1) Q903 more positive than Q901	1. Q903 open collector 2. VR902 open 3. VR901 zener voltage low or shorted	
(2) Q901 more positive than Q903	1. Q901 open collector 2. VR901 open 3. VR902 zener voltage low or shorted	
i. One or more of the following components shorted, opened or otherwise damaged: Q805, Q806, R839, R840, R841, R842, CR803 thru CR808	Inductive load or high voltage source applied to output BNC	Output amplifier will sustain an OUTPUT BNC short for indefinite periods without damage; however power source and inductive loads may cause amplifier failure
18. TRIANGLE LOOP Inoperative		
a. VLS TP502 = +3 Vdc and VLS TP501 = 5 Vdc and Δ AMP TP404 >3 Vdc	1. IC501 faulty (pin 9 $\leq$ 0.5 Vdc always) 2. Q503 open CE 3. Q504 shorted CE	
b. VLS TP502 = -3 Vdc and VLS TP501 = 5 Vdc and Δ AMP TP404 <-3 Vdc	1. IC501 faulty, (pin 9 $\geq$2.5 Vdc, always) 2. Q503 shorted CE 3. Q504 open	

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
c. VLS TP502 = +3 Vdc, Δ AMP TP402 >2.5 Vdc	1. Q405 faulty 2. IC 401 faulty 3. Q406 faulty	
d. VLS TP502 = +3 Vdc, Δ AMP TP402 <-2.5V	1. Q405 faulty 2. IC401 faulty 3. Q406 faulty	
e. VLS TP502 = +3 Vdc or -3V, Δ AMP TP404: 3.0 > V >-3.0V	1. Mode switch in GATE, TRIG or TRIG SWP position without TRIG SYNC input 2. One or more of the following capacitors shorted or leaky C405 thru C414 or shorted at TP401 or TP402 3. START/STOP faulty 4. LOGIC section faulty	 Check specific MULT range See part 24 See part 23
f. Δ AMP TP402 ≈ OV VLS TP501 ≈ OV VLS TP502 ≈ OV	1. Q501 or Q502 open emitter 2. Power supply disabled	 See part 21
g. TP404 = +5 Vdc (always)	1. IC401 faulty 2. Q406 open 3. Q405 shorted or faulty	
h. TP404 more negative than -5 Vdc	1. IC401 faulty 2. Q406 shorted 3. Q405 open	
19. FREQUENCY CONTROL Faults		
a. Frequency does not vary with dial	1. IC201 faulty 2. IC202 faulty	Check voltages shown on schematic

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
	3. No input at TP201; open wire to R201 FREQ potentiometer from E205, E203 or E206 4. Faulty S4 LOG/LIN switch (F47 only)	
b. Only positive slope of output ⏦ changes time as dial changes	1. Positive current generator inoperative 2. IC202 faulty 3. Q208 faulty	
c. Variable Symmetry feature inoperative	1. VAR SYM/NORM/X.01f switch in wrong position 2. Open wire from E221 to R248 VAR SYM potentiometer 3. Open wire from E217 to E413 4. Open wire from S5-2C MULT switch to R248 VAR SYM potentiometer	
d. Variable Symmetry features, does not have sufficient range at low end of dial	1. IC203 faulty 2. R251, R252, R255, R256 faulty	Check voltages at IC203 pins 11 and 5 shown on schematic
20. LOG CIRCUIT Faults		
a. Frequency does not vary with FREQ dial in LOG	1. Q202 or Q201 faulty 2. CR2 open	Check voltages at TP204 and TP202 shown on schematic
b. Large frequency error	-15V not being supplied to R515 via E213, S4 LOG/LIN switch; or E216	

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
c. FM on output on lowest decades of dial	Log loop oscillation; R218 or C202 faulty or open	
21. POWER SUPPLY		
a. All voltages at zero	1. Fuse blown, (S11 and or S12 in wrong positions) 2. S10, S11 open or intermittent	
b. All voltages too high	1. R909 misadjusted or open 2. IC901 faulty 3. VR903, Q902, Q901 shorted 4. VR901 open	
c. All voltages too low	1. Fault current on +15V lines 2. R909 misadjusted 3. VR903 much lower than 5.9V	
d. Negative regulated voltages low or zero	1. IC902 faulty 2. Fault current on -15V lines	
e. +5V too high	Q905 or Q904 shorted	
f. +5V too low	1. Fault current on +5V lines 2. C905 leaky or shorted 3. Q904 open	
g. -5V too far negative	Q910, Q909 shorted	
h. -5V too far positive	1. Fault current on -5V lines 2. C908 leaky or shorted	
22. SINE SHAPER Faults		
a. Excessive distortion	1. R703 or R722 misadjusted 2. Triangle amplitude, or amplitude symmetry time misadjusted	See Calibration Procedure

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
	3. IC702 or IC703 faulty 4. CR703 or CR704 faulty	
b. No sine at TP703 but O.K. at TP702	1. IC 701 faulty 2. VR701 open	
c. Clipped Waveforms	1. Q703, Q704 faulty 2. Q701, Q702, Q705 or Q706 faulty 3. R707 or R708 open	Check voltages shown on schematic
23. LOGIC faults		
a. No waveforms; Logic 1 at CR403 in CONT and other modes	1. Open CR40 or wire from E310 to E410 2. CR306 is shorted or grounded 3. Open wire from E314 to E411 4. Start/Stop faulty	
b. No waveforms for TRIG, GATE and TRIG SWP modes. Logic 1 at TP303 at all times	1. IC302 faulty 2. IC301 faulty 3. S7 open contact 1 to 2 4. Q301 faulty 5. Open wire TRIGGER LEVEL potentiometer to E304 6. Open COAX to E301 and E302 7. S6 faulty	See logic section timing diagrams
24. START/STOP		
a. No waveforms; Logic section O.K. Amp TP404 at 3.0 >V >-3.0V	1. Q401 or Q402 always OFF or open 2. Q403 always ON or shorted	

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
b. No waveforms, Logic section O.K., \ Amp TP404 at more negative than -3V	R403 misadjusted	See Calibration Procedure
c. No waveforms \ Amp TP404 more negative than -3 Vdc; VLS TP501 at -5 Vdc	Q404 shorted or faulty	
25. VARIABLE PULSE Faults		
a. TP601 at +5V independent of VAR PULSE position	Q601 shorted	
b. TP601 at -5V independent of VAR PULSE position	Q602 shorted	
c. TP601 at +3 Vdc independent of VAR PULSE position	1. Q603 open 2. Q604 shorted 3. Open wire from E608 to -15V	
d. TP601 at -3 Vdc independent of VAR PULSE position	1. Q603 shorted 2. Q604 open 3. Open wire from E607 to -5V	
e. TP601 at +3 Vdc >V> -3 Vdc or pulse amplitude low	601 or Q602 open collector or open base	

Table 5-1. Troubleshooting Guide (Continued)

Symptom	Possible Cause	Remarks
26. STEP CALIBRATOR Faults		
a. Step Calibrator does not produce equal steps between 0 and 10 (Linear)	1. LOG/LIN switch in LOG (F47) 2. Faulty resistor: R101 through R110 on S3 Step Calibrator switch faulty	
b. Step Calibrator produces only one or two frequencies	1. MODE switch not in CALIB mode 2. Open resistor: R101 through R110 on S3 Step Calibrator switch faulty 3. IC101 faulty 4. Open wire S3 wiper to E102	
27. SWP MARKER Faults		See part 5

Section 6
PARTS LIST

6-1. INTRODUCTION

This section contains information for identifying and ordering replacement parts. Replacement parts may be ordered from Interstate Electronics Corporation. Be certain that the order or inquiry identifies the part by description and part number.

6-2. PARTS LIST TABLES

Table 6-1 lists all electrical and electronic parts in alphanumeric order by reference designators and provides the following information for each part, where applicable: (a) value, (b) description, (c) manufacturer's code symbol, and (d) original manufacturer's part number.

The parts list applies to Models F41, F43, F44, F46 (the F46 A2 card is listed separately), and F47. Interstate Electronics Corporation reserves the right to substitute part numbers and/or manufacturers for any component or assembly. Where it appears, the asterisk (*) signifies that factory select values are nominal, not necessarily actual.

TABLE 6-1. PARTS LIST

Ref. Desig.	Value	Alternate Part No.	Preferred Part No.	Description	Manufacturer
CR001		FD333		Diode	Fairchild
CR002-CR704		IN4153		Diode	ITT
CR801-CR802		IN645		Diode	Texas Instruments
CR803-CR808		IN4153		Diode	ITT
CR901-CR904		IN4002		Diode	Motorola
C001-C002			P00347755	C:Matched Set	Interstate
C003	820PF	CM06CC-821J		C:Mica 300V ±5%	Sangamo
C004	20PF	CM05ED-200K		C:Mica 500V ±10%	Sangamo
C005	3.3PF	C030A102E3R3D		C:Ceramic 1000V ±0.5PF	Sprague
C006	150PF NOM	CM05ED-	Factory Select	C:Mica 500V ±10%	Sangamo
C007	75PF	CM05ED-750K		C:Mica 500V ±10%	Sangamo
C008-C009	47PF	CM05ED-470K		C:Mica 500V ±10%	Sangamo
C010	180PF NOM	CM05ED-	Factory Select	C:Mica 500V ±10%	Sangamo
C011	510PF	CM05ED-511K		C:Mica 500V ±10%	Sangamo
C012	0.1MF	C280AEA/100K	P00347721	C:Met Poly, 250V ±10%	Amperex
C014-C015	10PF	CM05ED-100K		C:Mica 500V ±10%	Sangamo
C016	100PF	CM05ED-101K		C:Mica 500V ±10%	Sangamo
C017-C018	0.1MF	C280AEA/100K	P00347721	C:Met Poly, 250V 10%	Amperex
C101	0.01MF	C023A101F103M		C:Ceramic 100V ±20%	Sprague
C201-C202	0.01MF	C023A101F103M		C:Ceramic 100V ±20%	Sprague
C203	6.8MF	196D685X0035KAI		C:Tant 35V ±10%	Sprague
C204-C206	0.01MF	C023A101F103M		C:Ceramic 100V ±20%	Sprague
C301	0.01MF	C023A101F103M		C:Ceramic 100V ±20%	Sprague
C302	0.1MF	C280AEA/100K	P00347721	C:Met Poly, 250V ±10%	Amperex
C303	150PF	CM05ED-151K		C:Mica 500V ±10%	Sangamo
C304	7PF	CM05ED-070K		C:Mica 500V ±10%	Sangamo
C305	200PF	CM05ED-201K		C:Mica 500V ±10%	Sangamo
C306	1000PF	C016A102G102M		C:Ceramic 1000V ±10%	Sprague
C401	15PF	CM05CD-150K		C:Mica 500V ±10%	Sangamo
C402	240PF	CM05ED-241K	CM05ED-241K	C:Mica 500V ±10%	Sangamo
C403	47PF	CM05ED-470K	CM05ED-470K	C:Mica 500V ±10%	Sangamo
C404	150PF	CM05ED-151K	CM05ED-151K	C:Mica 500V ±10%	Sangamo
C405-C408			PR0347750E	Capacitor, Matched Set	Interstate
C409	820PF	CM06CC-821J		C:Mica 300V ±5%	Sangamo
C410	47PF NOM	CM05ED-	Factory Select	C:Mica 500V ±10%	Sangamo
C411-C412	2.4-24.5PF	189-509-5	189-509-5	C:Var Air Dielectric	E.F. Johnson
C413	20PF	CM05ED201K		C:Mica 500V ±10%	Sangamo
C414	27PF	CM05ED-270G		C:Mica 500V ±2%	Sangamo
C415	0.01MF	C023A101F103M		C:Ceramic 100V ±20%	Sprague
C416	10PF	CM05ED-100K		C:Mica 500V ±10%	Sangamo
C417	7PF	CM05ED-070K		C:Mica 500V ±10%	Sangamo
C418	12PF	CM05ED-120J		C:Mica 500V ±10%	Sangamo
C419	33PF NOM	CM05ED-	Factory Select	C:Mica 500V ±10%	Sangamo
C420-C421	0.01MF	C023A101F103M		C:Ceramic 100V ±20%	Sprague
C501	82PF	CM05ED-820J		C:Mica 500V ±10%	Sangamo
C502-C503	0.1MF	C280AEA/100K	P00347721	C:Met Poly, 250V ±10%	Amperex
C504	0.01MF	C023A101F103M		C:Ceramic 100V ±20%	Sprague
C505	2.4-24.5PF	189-509-5		C:Var Air Dielectric	E.F. Johnson
C506	56PF NOM		Factory Select	C:Mica 500V ±10%	Sangamo
C507-C508	10PF	CM05ED-100K		C:Mica 500V ±10%	Sangamo

Ref. Desig.	Value	Alternate Part No.	Preferred Part No.	Description	Manufacturer
C509	36PF	CM05ED-360K		C:Mica 500V ±10%	Sangamo
C510-C511	0.1MF	C280AEA/100K	P00347721	C:Met Poly, 250V ±10%	Amperex
C512	3PF	CM05ED-	Factory Select	C:Mica 500V ±10%	Sangamo
C513	3-30PF	9303		C:Var Ceramic Dielectric	Johanson Mfg.
C601	20PF	CM05ED-200K		C:Mica 500V ±10%	Sangamo
C602	3.3PF	C030A102E3R3D		C:Ceramic 1000V ±0.5PF	Sprague
C603	0.01MF	C023A101F103M		C:Ceramic 100V ±20%	Sprague
C604-C605	0.1MF	C280AEA/100K	P00347721	C:Met Poly, 250V ±10%	Amperex
C701	0.1MF	C280AEA/100K	P00347721	C:Met Poly, 250V ±10%	Amperex
C702	2.3-20PF	9302		C:Var Ceramic Dielectric	Johanson Mfg.
C703	510PF	CM05ED-511K		C:Mica 500V ±10%	Sangamo
C704	10PF	CM05ED-100K		C:Mica 500V ±10%	Sangamo
C705	0.1MF	C280AEA/100K	P00347721	C:Met Poly, 250V ±10%	Amperex
C706	0.01MF	C023A101F103M		C:Ceramic 100V ±20%	Sprague
C707	27PF	CM05ED-270K		C:Mica 500V ±10%	Sangamo
C708	6.8MF	196D685X0035KAI		C:Tant 35V ±10%	Sprague
C801	0.1MF	C280AEA/100K	P00347721	C:Met Poly, 250V ±10%	Amperex
C803	3-30PF	9303		C:Var Ceramic Dielectric	Johanson Mfg.
C804-C805	0.01MF	C023A101F103M		C:Ceramic 100V ±20%	Sprague
C806-C807	3.3MF	196D335X9050JA1		C:Tant 50V ±10%	Sprague
C808	0.01MF	C023A101F103M		C:Ceramic 100V ±20%	Sprague
C809-C810	0.01MF	C023A101F103M		C:Ceramic 100V ±20%	Sprague
C811-C812	3.3MF	196D335X9050JA1		C:Tant 50V ±10%	Sprague
C813	0.1MF	C280AEA/100K		C:Met Poly, 250V ±10%	Amperex
C814-C815	6.8MF	196D685X0035KAI		C:Tant 35V ±10%	Sprague
C901	0.01MF	5GAS10	C023A102K103M	C:Ceramic 1000V 20%	Sprague
C902-C903	2500MF		P00347706	C:Elect 50V -10 +25%	Interstate
C904	100MF		P00347704	C:Elect 50V -10 +25%	Interstate
C905	100MF	20-44823		C:Elect 15V -10 +100%	Mallory
C906	0.01MF	C023A101F103M		C:Ceramic 100 Volts ±20%	Sprague
C907	100MF		P00347704	C:Elect 50V -10 +25%	Interstate
C908	100MF	20-44823		C:Elect 15V -10 +100%	Mallory
C909	0.01MF	C023A101F103M		C:Ceramic 100V +20%	Sprague
C910	0.01MF	C280AEA/100K		C:Met Poly, 250V ±10%	Amperex
C911	6.8MF	196D685X0035KAI		C:Tant 35V ±10%	Sprague
C912	100PF	CM05ED-101K		C:Mica 500V ±10%	Sprague
IC001		CA3030		Int Circuit, OP Amp	RCA
IC002		SN72710N		Int Circuit, Comparator	Texas Instruments
IC102		SN72710N		Int Circuit, Comparator	Texas Instruments
IC201		NE5558V		Int Circuit, Dual OP Amp	Signetics
IC202-IC203		CA3096AE		Int Circuit, Trans Array	RCA
IC301		SN72710N		Int Circuit, Comparator	Texas Instruments
IC302		SN7400N		Int Circuit, Quad Gate	Texas Instruments
IC401		CA3086		Int Circuit, Trans Array	RCA
IC501		SN72710N		Int Circuit, Comparator	Texas Instruments
IC502		SN7404N		Int Circuit, Hex Inverter	Texas Instruments
IC701		CA3086		Int Circuit, Trans Array	RCA
IC702-IC703		CA3039		Int Circuit, Diode Array	RCA
IC801		CA3018A		Int Cir Trans Array	RCA
IC901-IC902		SN72741P		Int Circuit, OP Amp	Texas Instruments

Table 6-1. Parts List (Continued)

Ref. Desig.	Value	Alternate Part No.	Preferred Part No.	Description	Manufacturer
L701	62 uH	9210-66	9210-66	Inductor	J.W. Miller
Q001		2N3906	P00347102	Transistor PNP	Texas Instruments
Q002			P00347201	Transistor DUAL N JFET	Interstate
Q003		2N5770		Transistor NPN	Interstate
Q004		2N3904	P00347001	Transistor NPN	Texas Instruments
Q005		2N2369A	2N2369A	Transistor NPN	Texas Instruments
Q006		2N3904	P00347001	Transistor NPN	Texas Instruments
Q201		2N5485	2N5485	Transistor N JFET	Motorola
Q202		TD501	TD501	Transistor DUAL PNP	Sprague
Q203-Q205		2N3906	P00347102	Transistor PNP	Texas Instruments
Q206-Q207		2N3904	P00347001	Transistor NPN	Texas Instruments
Q208		2N5462	2N5462	Transistor P JFET	Motorola
Q209-Q301		2N3906	P00347102	Transistor PNP	Texas Instruments
Q401		2N5771	2N5771	Transistor PNP	Fairchild
Q402-Q403		2N3904	P00347001	Transistor NPN	Texas Instruments
Q404		2N5771	2N5771	Transistor PNP	Fairchild
Q405			P00347206	Transistor N JFET	Interstate
Q406-Q501		2N3904	P00347001	Transistor NPN	Texas Instruments
Q502		2N3906	P00347102	Transistor PNP	Texas Instruments
Q503-Q505		2N3904	P00347001	Transistor NPN	Texas Instruments
Q506		2N3906	P00347102	Transistor PNP	Texas Instruments
Q507		2N3904	P00347001	Transistor NPN	Texas Instruments
Q601		2N3904	P00347001	Transistor NPN	Texas Instruments
Q602		2N3906	P00347102	Transistor PNP	Texas Instruments
Q603-Q604		2N3904	P00347001	Transistor NPN	Texas Instruments
Q701		2N3906	P00347102	Transistor PNP	Texas Instruments
Q702-Q703		2N3904	P00347001	Transistor NPN	Texas Instruments
Q704-Q705		2N3906	P00347102	Transistor PNP	Texas Instruments
Q706		2N3904	P00347001	Transistor NPN	Texas Instruments
Q801		2N2905A	2N2905A	Transistor PNP	Texas Instruments
Q802		2N2219A	2N2219A	Transistor NPN	Texas Instruments
Q803		MPS-U56	MPS-U56	Transistor PNP	Motorola
Q804-Q805		MPS-U06	MPS-U06	Transistor NPN	Motorola
Q806		MPS-U56	MPS-U56	Transistor PNP	Motorola
Q901		TIP-29A	TIP-29A	Transistor NPN	Texas Instruments
Q902		2N2219A	2N2219A	Transistor NPN	Texas Instruments
Q903-Q904		2N3904	P00347001	Transistor NPN	Texas Instruments
Q905-Q906		2N2905A	2N2905A	Transistor PNP	Texas Instruments
Q907		TIP-30A	TIP-30A	Transistor PNP	Texas Instruments
Q908-Q909		2N3906	P00347102	Transistor PNP	Texas Instruments
Q910		2N2219A	2N2219A	Transistor NPN	Texas Instruments
R001	1.33K	RN60D1331F	P00347601-1331	R:Metal Film 1/2 watt 1%	Corning
R002	43Ω	RG1/4-430J	P00347620-430	R:Metal Glaze 1/4 watt 1%	TRW/IRC
R003	10K		P00347913 (See S1)	Potentiometer	Interstate
R004	2.5K	TSV-2.5V	P00347679-252	R:Trim 1/4 watt ±30%	CTS
R005	66.5K	RN60D6652F	P00347601-6652	R:Metal Film 1/2 watt 1%	Corning
R006	2.2M	RC20GF225J		R:Carbon 1/2 watt 5%	TRW/IRC
R007	5.49K	RN60D5491F	P00347601-5491	R:Metal Film 1/2 watt 1%	Corning
R008	215K	RN60D2153F	P00347601-2153	R:Metal Film 1/2 watt 1%	Corning
R009	21.5K	RN60D2152F	P00347601-2152	R:Metal Film 1/2 watt 1%	Corning

Ref. Desig.	Value	Alternate Part No.	Preferred Part No.	Description	Manufacturer
R010	3.3K	RG1/4-332J	P00347620-332	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R011	2K	RG1/4-202J	P00347620-202	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R012	4.7K	RG1/4-472J	P00347620-472	R:Metal Glaze 1/4 watt	TRW/IRC
R013	10.0K	RN60D1002F	P00347601-1002	R:Metal Film 1/2 watt 1%	Corning
R014	30.1K	RN60D3012F	P00347601-3012	R:Metal Film 1/2 watt 1%	Corning
R015	10.0K	RN60D1002F	P00347601-1002	R:Metal Film 1/2 watt 1%	Corning
R016	30.1K	RN60D3012F	P00347601-3012	R:Metal Film 1/2 watt 1%	Corning
R017	20K	RG1/4-203J	P00347620-203	R:Metal Film 1/2 watt 1%	TRW/IRC
R018	1.8M	GBT1/4-185J	P00347620-185	R:Carbon 1/4 watt 1%	TRW/IRC
R019	50K	TSV-50K	P00347679-503	R:Trim 1/4 watt ±30%	CTS
R020	47K	RG1/4-473J	P00347620-473	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R021	4.7K	RG1/4-472J	P00347620-472	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R022	2.2K	RG1/4-222J	P00347620-222	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R023	6.8K	RG1/4-682J	P00347620-682	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R025	4.7K	RG1/4-472J	P00347620-472	R:Metal Glaze 1/2 watt 5%	TRW/IRC
R026	36K	RG1/4-363J	P00347620-363	R:Metal Glaze 1/2 watt 5%	TRW/IRC
R027-R028	1K	RG1/4-102J	P00347620-102	R:Metal Glaze 1/2 watt 5%	TRW/IRC
R029	50K	TSV-50K	P00347679-503	R:Trim 1/4 watt ±30%	CTS
R030	1.5K	RG1/4-152J	P00347620-152	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R031	1M	GBT1/4-105J	P00347620-105	R:Carbon 1/4 watt 5%	TRW/IRC
R032	1K	RG1/4-102J	P00347620-102	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R033	100Ω	TSV-100	P00347679-101	R:Trim 1/4 watt ±30%	CTS
R034	2.00K	RN60D2001F	P00347601-2001	R:Metal Film 1/2 watt 1%	Corning
R035	715Ω	RN60D7150F	P00347601-7150	R:Metal Film 1/2 watt 1%	Corning
R036	390	RG1/4-391J	P00347620-391	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R037	1.5K	RG1/4-152J	P00347620-152	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R038	560	RG1/4-561J	P00347620-561	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R039	3.6K	RG1/4-362J	P00347620-362	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R040	51Ω	RG1/4-510J	P00347620-510	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R041	100Ω	RG1/4-101J	P00347620-101	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R042	2.00K	RN60D2001F	P00347601-2001	R:Metal Film 1/2 watt 1%	Corning
R043	68K	RG1/4-683J	P00347620-683	R:Metal Glaze 1/4 watt ±5%	TRW/IRC
R044	1K	RG1/4-102J	P00347620-102	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R045	1.5K	RG1/4-152J	P00347620-152	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R046	820	RG1/4-821J	P00347620-821	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R047	6.8K	RG1/4-682J	P00347620-682	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R048	1M	GBT1/4-105J	P00347620-105	R:Carbon 1/4 watt 5%	TRW/IRC
R101-R110	100Ω	RN60D1000F	P00347601-1000	R:Metal Film 1/2 watt 1%	Corning
R111	50K	TSV-50K	P00347679-503	R:Trim 1/4 watt ±30%	CTS
R112	1M	GBT1/4-105J	P00347620-105	R:Carbon 1/4 watt 5%	TRW/IRC
R113	3.32K	RN60D3321F	P00347601-3321	R:Metal Film 1/2 watt 1%	Corning
R114	9.09K	RN60D9091F	P00347601-9091	R:Metal Film 1/2 watt 1%	Corning
R115	2.5K	TSV-2.5K	P00347679-252	R:Trim 1/4 watt ±30%	CTS
R116	51Ω	RG1/4-510J	P00347620-510	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R117	470Ω	RG1/4-471J	P00347620-471	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R118	47K	RG1/4-473K	P00347620-473	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R119 (F44)	1K		P00347698-4	Potentiometer 1K ±10%	Interstate
R119 (F47)	10K		P00347915-2	Potentiometer 10K ±10%	Interstate
R120	49.9Ω	RN60D49R9F	P00347601-49R9	R:Metal Film 1/2 watt 1%	Corning
R121	9.09K	RN60D9091F	P00347601-9091	R:Metal Film 1/2 watt 1%	Corning

Table 6-1. Parts List (Continued)

Ref. Desig.	Value	Alternate Part No.	Preferred Part No.	Description	Manufacturer
R122	49.9Ω	RN60D49R9F	P0347601-49R9	R:Metal Film 1/2 watt 1%	Corning
R123 (F41/F43)	9.53K	RN60D9531F	P0347601-9531	R:Metal Film 1/2 watt ±1%	Corning
R123 (F44)	5.76K	RN60D5761F	P0347601-5761	R:Metal Film 1/2 watt ±1%	Corning
R123 (F47/F46)	None				
R124	8.06K	RN60D8061F	P0347601-8061	R:Metal Film 1/2 watt 1%	Corning
R201	1K		P0347698-1	Potentiometer	Interstate
R202	845Ω	RN60D8450F	P0347601-8450	R:Metal Film 1/2 watt 1%	Corning
R203	1K		P0347698-1	Potentiometer	Interstate
R204	250Ω	TSV-250	P0347679-251	R:Trim 1/4 watt ±30%	CTS
R205	750Ω	RN60D7500F	P0347601-7500	R:Metal Film 1/2 watt 1%	Corning
R206	22.1K or	RN60D2212F	P0347601-2212	R:Metal Film 1/2 watt 1%	Corning
R206 (F46)	36.5K	RN60D3652F	P0347601-3652	R:Metal Film 1/2 watt 1%	Corning
R207	49.9K	RN60D4992F	P0347601-4992	R:Metal Film 1/2 watt 1%	Corning
R208	4.64K	RN60D4641F	P0347601-4641	R:Metal Film 1/2 watt 1%	Corning
R209	100	TSV-100	P0347679-101	R:Trim 1/4 watt ±30%	CTS
R210	17.4K	RN60D1742F	P0347601-1742	R:Metal Film 1/2 watt 1%	Corning
R211	17.4K	RN60D1742F	P0347601-1742	R:Metal Film 1/2 watt 1%	Corning
R212	2.5K	TSV-2.5K	P0347679-252	R:Trim 1/4 watt ±30%	CTS
R213	332Ω	RN60D3320F	P0347601-3320	R:Metal Film 1/2 watt 1%	Corning
R214	14.3K	RN60D1432F	P0347601-1432	R:Metal Film 1/2 watt 1%	Corning
R215	2.5K	TSV-2.5K	P0347679-252	R:Trim 1/4 watt ±30%	CTS
R216	6.98K	RN60D6981F	P0347601-6981	R:Metal Film 1/2 watt 1%	Corning
R217	1K	RG1/4-102J	P0347620-102	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R218	2K	RG1/4-202J	P0347620-202	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R219	8.06K	RN60D8061F	P0347601-8061	R:Metal Film 1/2 watt 1%	Corning
R220	5.6K	RG1/4-562J	P0347620-562	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R221	15K	RG1/4-153J	P0347620-153	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R222	3.6K	RG1/4-362J	P0347620-362	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R223	3.0K	RG1/4-302J	P0347620-302	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R224	750Ω	RN60D7500F	P0347601-7500	R:Metal Film 1/2 watt 1%	Corning
R225	604Ω	RN60D6040F	P0347601-6040	R:Metal Film 1/2 watt 1%	Corning
R226	7.68K	RN60D7681F	P0347601-7681	R:Metal Film 1/2 watt 1%	Corning
R227	4.87K	RN60D4871F	P0347601-4871	R:Metal Film 1/2 watt 1%	Corning
R228	39K	RG1/4-393J	P0347620-393	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R229	50K	TSV-50K	P0347679-503	R:Trim 1/4 watt ±30%	CTS
R230	20K	RG1/4-203J	P0347620-203	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R231	2.49K	RN60D2491F	P0347601-2491	R:Metal Film 1/2 watt 1%	Corning
R232	15K	RG1/4-153J	P0347620-153	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R233	10K	TSV-10K	P0347679-103	R:Trim 1/4 watt ±30%	CTS
R234	133K	RN60D1333F	P0347601-1333	R:Metal Film 1/2 watt 1%	Corning
R235	100Ω	TSV-100	P0347679-101	R:Trim 1/4 watt ±30%	CTS
R236	1.33K	RN60D1331F	P0347601-1331	R:Metal Film 1/2 watt 1%	Corning
R237	133K	RN60D1333F	P0347601-1333	R:Metal Film 1/2 watt 1%	Corning
R238	2.61K	RN60D2611F	P0347601-2611	R:Metal Film 1/2 watt 1%	Corning
R239	1.37K	RN60D1371F	P0347601-1371	R:Metal Film 1/2 watt 1%	Corning
R240	15K NOM	Factory Select	P0347601-	R:Metal Film 1/2 watt 1%	Corning
R241-R242	100	RG1/4-101J	P0347620-101	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R243	4.87K	RN60D4871F	P0347601-4871	R:Metal Film 1/2 watt 1%	Corning
R244	1.37K	RN60D1371F	P0347601-1371	R:Metal Film 1/2 watt 1%	Corning
R245	2.61K	RN60D2611F	P0347601-2611	R:Metal Film 1/2 watt 1%	Corning

Ref. Desig.	Value	Alternate Part No.	Preferred Part No.	Description	Manufacturer
R246	133K	RN60D1333F	P0347601-1333	R:Metal Film 1/2 watt 1%	Corning
R247	1.37K	RN60D1371F	P0347601-1371	R:Metal Film 1/2 watt 1%	Corning
R248	25K		P0347905-2	Potentiometer (see S8)	Interstate
R249	2.61K	RN60D2611F	P0347601-2611	R:Metal Film 1/2 watt 1%	Corning
R250	133K	RN60D1333F	P0347601-1333	R:Metal Film 1/2 watt 1%	Corning
R251	787Ω	RN60D7870F	P0347601-7870	R:Metal Film 1/2 watt 1%	Corning
R252	14.3K	RN60D1432F	P0347601-1432	R:Metal Film 1/2 watt 1%	Corning
R253	10K	TSV-10K	P0347679-103	R:Trim 1/4 watt ±30%	CTS
R254	5.1K	RG1/4-512J	P0347620-512	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R255	787Ω	RN60D7870F	P0347601-7870	R:Metal Film 1/2 watt 1%	Corning
R256	14.3K	RN60D1432F	P0347601-1432	R:Metal Film 1/2 watt 1%	Corning
R301	10K		P0347916-2	Potentiometer (see S6)	Interstate
R302	30K	RG1/4-303J	P0347620-303	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R303	10K	RC32GF103J	RC32GF103J	R:Carbon 1 watt 5%	TRW/IRC
R304	390	RG1/4-391J	P0347620-391	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R305	4.7K	RG1/4-472J	P0347620-472	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R306	47K	RG1/4-473J	P0347620-473	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R307	10K	RG1/4-103J	P0347620-103	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R308	620Ω	RG1/4-681J	P0347620-621	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R309	4.7K	RG1/4-472J	P0347620-472	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R310	2.2K	RG1/4-222J	P0347620-222	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R311	390	RG1/4-391J	P0347620-391	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R312	15M	RC07GF156J	RC07GF156J	R:Carbon 1/4 watt 5%	
R313	1K	RG1/4-102J	P0347620-102	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R314	1.5K	RG1/4-152J	P0347620-152	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R315	2.2K	RG1/4-222J	P0347620-222	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R316	10	RG1/4-100J	P0347620-100	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R401(F43,F44,F47)	3K	RG1/4-302J	P0347620-302	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R401(F46)	6.2K	RG1/4-622J	P0347670-622	R:Metal Glaze 1/4 watt 5%	
R402	1.2K	RG1/4-122J	P0347620-122	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R403	1K	TSV-1K	P0347679-102	R:Trim 1/4 watt ±30%	CTS
R404	1.5K	RG1/4-152J	P0347620-152	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R405	910	RG1/4-911J	P0347620-911	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R406	100 NOM	Factory Select	P0347620-101	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R407	1K		P0347698-1	Potentiometer, Phase	Interstate
R408	10	RG1/4-100J	P0347620-100	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R409	470	RG1/4-471J	P0347620-471	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R410	10	RG1/4-100J	P0347620-100	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R411	360	RG1/4-361J	P0347620-361	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R412	2.2K	RG1/4-222J	P0347620-222	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R413	1.1K	RG1/4-112J	P0347620-112	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R414	8.2K	RG1/4-822J	P0347620-822	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R415	3.9K	RG1/4-392J	P0347620-392	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R416	4.7K	RG1/4-472J	P0347620-472	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R417	10	RG1/4-100J	P0347620-100	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R418	500	TSV-500	P0347679-501	R:Trim 1/4 watt ±30%	CTS
R419	2.2K	RG1/4-222J	P0347620-222	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R420	3.3K	RG1/4-332J	P0347620-332	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R421	390	RG1/4-391J	P0347620-391	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R422	3.3K	RG1/4-332J	P0347620-332	R:Metal Glaze 1/4 watt 5%	TRW/IRC

Table 6-1. Parts List (Continued)

Ref. Desig.	Value	Alternate Part No.	Preferred Part No.	Description	Manufacturer
R423	1.1K	RG1/4-112J	P00347620-112	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R424	3.6K	RG1/4-362J	P00347620-362	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R425	82.5Ω	RN60D82R5F	P00347601-8250	R:Metal Film 1/2 watt 1%	Corning
R426	2.49K	RN60D2491F	P00347601-2491	R:Metal Film 1/2 watt 1%	Corning
R427	200Ω	RG1/4-201J	P00347620-201	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R428	51Ω	RG1/4-510J	P00347620-510	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R429	1.3K	RG20-132J	P00347621-132	R:Metal Glaze 1/2 watt 5%	TRW/IRC
R430	510	RG1/4-511J	P00347620-511	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R431	620	RG1/4-621J	P00347620-621	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R432	51Ω	RG1/4-510J	P00347620-510	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R433	750Ω	RG1/4-751J	P00347620-751	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R434	510Ω	RG1/4-511J	P00347620-511	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R501	5.1K	RG1/4-512J	P00347620-512	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R502	1M	GBT1/4-105J	P00347620-105	R:Carbon 1/4 watt 5%	TRW/IRC
R503	27K	RG1/4-273J	P00347620-273	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R504	1.50K	RN60D1501F	P00347601-1501	R:Metal Film 1/2 watt 1%	Corning
R505	3.01K	RN60D3011F	P00347601-3011	R:Metal Film 1/2 watt 1%	Corning
R506	390Ω	RG1/4-391J	P00347620-391	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R507	100Ω	RG1/4-101J	P00347620-101	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R508	976Ω	RN60D9760F	P00347601-9760	R:Metal Film 1/2 watt 1%	Corning
R509	100	TSV-100	P00347679-101	R:Trim 1/4 watt ±30%	CTS
R510	6.19K	RN60D6191F	P00347601-6191	R:Metal Film 1/2 watt 1%	Corning
R511	5.76K	RN60D5761F	P00347601-5761	R:Metal Film 1/2 watt 1%	Corning
R512	1K	TSV-1K	P00347679-102	R:Trim 1/4 watt ±30%	CTS
R513	51Ω	RG1/4-510J	P00347620-510	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R514	2K	RG1/4-202J	P00347620-202	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R515	2.37K	RN60D2371F	P00347601-2371	R:Metal Film 1/2 watt 1%	Corning
R516	1.82K	RN60D1821F	P00347601-1821	R:Metal Film 1/2 watt 1%	Corning
R517	1K	RG1/4-102J	P00347620-102	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R518	1.5K	RG1/4-152J	P00347620-152	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R519	301Ω	RN60D3010F	P00347601-3010	R:Metal Film 1/2 watt 1%	Corning
R520	3.01K	RN60D3011F	P00347601-3011	R:Metal Film 1/2 watt 1%	Corning
R521	2.32K	RN60D2321F	P00347601-2321	R:Metal Film 1/2 watt 1%	Corning
R522	1.3K	RG20-132J	P00347621-132	R:Metal Glaze 1/2 watt 5%	TRW/IRC
R523	3.74K	RN60D3741F	P00347601-3741	R:Metal Film 1/2 watt 1%	Corning
R524	3.57K	RN60D3571F	P00347601-3571	R:Metal Film 1/2 watt 1%	Corning
R525	500Ω	TSV-500	P00347679-501	R:Trim 1/4 watt ±30%	CTS
R526	7.50K	RN60D7501F	P00347601-7501	R:Metal Film 1/2 watt 1%	Corning
R527	250Ω	TSV-250	P00347679-251	R:Trim 1/4 watt ±30%	CTS
R528	1.30K	RN60D1301F	P00347601-1301	R:Metal Film 1/2 watt 1%	Corning
R529	7.50K	RN60D7501F	P00347601-7501	R:Metal Film 1/2 watt 1%	Corning
R530	200Ω	RG20-201J	P00347621-201	R:Metal Glaze 1/2 watt 5%	TRW/IRC
R531	10Ω	RG1/4-100J	P00347620-100	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R532	39Ω	RG1/4-390J	P00347620-390	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R533	10Ω	RG1/4-100J	P00347620-100	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R534	200Ω	RG20-201J	P00347621-201	R:Metal Glaze 1/2 watt 5%	TRW/IRC
R535-R536	200Ω	RG1/4-201J	P00347620-201	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R537-R538	10Ω	RG1/4-100J	P00347620-100	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R601-602	10Ω	RG1/4-100J	P00347620-100	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R603	7.50K	RN60D7501F	P00347601-7501	R:Metal Film 1/2 watt 1%	Corning

Ref. Desig.	Value	Alternate Part No.	Preferred Part No.	Description	Manufacturer
R604	3.32K	RN60D3321F	P00347601-3321	R:Metal Film 1/2 watt 1%	Corning
R605	1.18K	RN60D1181F	P00347601-1181	R:Metal Film 1/2 watt 1%	Corning
R606	7.50K	RN60D7501F	P00347601-7501	R:Metal Film 1/2 watt 1%	Corning
R607	1.30K	RN60D1301F	P00347601-1301	R:Metal Film 1/2 watt 1%	Corning
R608	3.32K	RN60D3321F	P00347601-3321	R:Metal Film 1/2 watt 1%	Corning
R609	100	RG1/4-101J	P00347620-101	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R610	1.21K	RN60D1211F	P00347601-1211	R:Metal Film 1/2 watt 1%	Corning
R611	43K	RG1/4-433J	P00347620-433	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R612	7.87K	RN60D7871F	P00347601-7871	R:Metal Film 1/2 watt 1%	Corning
R613	4.99K	RN60D4991F	P00347601-4991	R:Metal Film 1/2 watt 1%	Corning
R614	10	RG1/4-100J	P00347620-100	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R615	2.5K		P00347905-2	Potentiometer (see S8)	Interstate
R616	39	RG1/4-390J	P00347620-390	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R618	3.01K	RN60D3011F	P00347601-3011	R:Metal Film 1/2 watt 1%	Corning
R619-R620	590	RN60D5900F	P00347601-5900	R:Metal Film 1/2 watt 1%	Corning
R621	3.01K	RN60D3011F	P00347601-3011	R:Metal Film 1/2 watt 1%	Corning
R623	680	RG1/4-681J	P00347620-681	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R701	1.47K	RN60D1471F	P00347601-1471	R:Metal Film 1/2 watt 1%	Corning
R702	500	TSV-500	P00347679-501	R:Trim 1/4 watt ±30%	CTS
R703	13.0K	RN60D1302F	P00347601-1302	R:Metal Film 1/2 watt 1%	Corning
R704	20K	RG1/4-203J	P00347620-203	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R705	47	RG1/4-470J	P00347620-470	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R706	51	RG1/4-510J	P00347620-510	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R707	1K	TSV-1K	P00347679-102	R:Trim 1/4 watt ±30%	CTS
R708	3.09K	RN60D3091F	P00347601-3091	R:Metal Film 1/2 watt 1%	Corning
R709	2.00K	RN60D2001F	P00347601-2001	R:Metal Film 1/2 watt 1%	Corning
R710	3.09K	RN60D3091F	P00347601-3091	R:Metal Film 1/2 watt 1%	Corning
R711	2.49K	RN60D2491F	P00347601-2491	R:Metal Film 1/2 watt 1%	Corning
R712	47K	RG1/4-473J	P00347620-473	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R713	1.2K	RG1/4-122J	P00347620-122	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R714	1.2K	RG20-122J	P00347621-122	R:Metal Glaze 1/2 watt 5%	TRW/IRC
R715	82.5Ω	RN60D82R5	P00347601-82R5	R:Metal Film 1/2 watt 5%	Corning
R716	10K	RG1/4-103J	P00347620-103	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R717	47	RG1/4-470J	P00347620-470	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R718	20K	RG1/4-203J	P00347620-203	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R719	1M	GBT1/4-105J	P00347620-105	R:Carbon 1/4 watt 5%	TRW/IRC
R720	50K	TSV-50K	P00347679-503	R:Trim 1/4 watt ±30%	CTS
R721	13.0K		P00347601-1302	R:Metal Film 1/2 watt 1%	Corning
R722	500	TSV-500	P00347679-501	R:Trim 1/4 watt ±30%	CTS
R723	1.47K		P00347601-1471	R:Metal Film 1/2 watt 1%	Corning
R724			P00347401	Resistor Network	Interstate
R725	66.5Ω	RN60D66R5F	P00347601-66R5	R:Metal Film 1/2 watt 1%	Corning
R726	10K	RG1/4-103J	P00347620-103	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R727			P00347404	Resistor Network	Interstate
R728	4.7K	RG1/4-472J	P00347620-472	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R729			P00347401	Resistor Network	Interstate
R730	66.5Ω	RN60D66R5F	P00347601-66R5	R:Metal Film 1/2 watt 1%	Corning
R801	10K		P00347910	Potentiometer (see S9)	Interstate

Table 6-1. Parts List (Continued)

Ref. Desig.	Value	Alternate Part No.	Preferred Part No.	Description	Manufacturer
R802	1.18K	RN60D1181F	P00347601-1181	R:Metal Film 1/2 watt 1%	Corning
R803	8.87K	RN60D8871F	P00347601-8871	R:Metal Film 1/2 watt 1%	Corning
R804	1K		P00338750-2	Potentiometer (see S14)	Interstate
R805	24Ω	RG1/4-240J	P00347620-240	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R807	51K	RG1/4-513J	P00347620-513	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R808	24Ω	RG1/4-240J	P00347620-240	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R809	2.43K	RN60D2431F	P00347601-2431	R:Metal Film 1/2 watt 1%	Corning
R810	24	RG1/4-240J	P00347620-240	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R811	51K	RG1/4-513J	P00347620-513	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R812	1M	GBT1/4-105J	P00347620-105	R:Carbon 1/4 watt 5%	TRW/IRC
R813	1.2K	RG1/4-122J	P00347620-122	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R814	50K	TSV-50K	P00347679-503	R:Trim 1/4 watt ±30%	CTS
R815	2.00K	RN60D2001F	P00347601-2001	R:Metal Film 1/2 watt 1%	Corning
R816	1.10K	RN60D1101F	P00347601-1101	R:Metal Film 1/2 watt 1%	Corning
R817	9.53K	RN60D9531F	P00347601-9531	R:Metal Film 1/2 watt 1%	Corning
R818	3.01K	RN60D3011F	P00347601-3011	R:Metal Film 1/2 watt 1%	Corning
R819	1K	TSV-1K	P00347679-102	R:Trim 1/4 watt ±30%	CTS
R820	475Ω	RN60D4750F	P00347601-4750	R:Metal Film 1/2 watt 1%	Corning
R821	1.40K	RN60D1401F	P00347601-1401	R:Metal Film 1/2 watt 1%	Corning
R822	953Ω	RN60D9530F	P00347601-9530	R:Metal Film 1/2 watt 1%	Corning
R823	2.74K	RN60D2741F	P00347601-2741	R:Metal Film 1/2 watt 1%	Corning
R824-R825	390		RC42GF391J	R:Carbon 2 watts 5%	TRW/IRC
R826	5.1		RC07GF5R1J	R:Carbon 1/4 watt 5%	TRW/IRC
R827	51		RC32GF510J	R:Carbon 1 watt 5%	TRW/IRC
R828-R829	5.1		RC07GF5R1J	R:Carbon 1/4 watt 5%	TRW/IRC
R830	51		RC32GF510J	R:Carbon 1 watt 5%	TRW/IRC
R831	5.1		RC07GF5R1J	R:Carbon 1/4 watt 5%	TRW/IRC
R832	1.40K	RN60D1401F	P00347601-1401	R:Metal Film 1/2 watt 1%	Corning
R833	2.74K	RN60D2741F	P00347601-2741	R:Metal Film 1/2 watt 1%	Corning
R834	475	RN60D4750F	P00347601-4750	R:Metal Film 1/2 watt 1%	Corning
R835	953Ω	RN60D9530F	P00347601-9530	R:Metal Film 1/2 watt 1%	Corning
R836	91Ω	RG1/4-910J	P00347620-910	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R837-R838	6.2Ω		RC32GF6R2J	R:Carbon 1 watt 5%	TRW/IRC
R839-R842	51Ω		RL42S510G	R:Metal Film 2 watts 2%	TRW/IRC
R901	2.7K	RG1/4-272J	P00347620-272	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R902	2.7Ω		RC20GF2R7J.	R:Carbon 1/2 watt 5%	TRW/IRC
R903	390Ω	RG1/4-391J	P00347620-391	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R904	15K	RG1/4-153J	P00347620-153	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R905	470Ω	RG1/4-471J	P00347620-471	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R906	1.2K	RG1/4-122J	P00347620-122	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R907	5.6K	RG1/4-562J	P00347620-562	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R908	15.0K		P00347607-1502	R:Metal Film 1/2 watt 1% ±25 ppm	Corning
R909	2.5K	TSV-2.5K	P00347679-252	R:Trim 1/4 watt ±30%	CTS
R910	10.0K		P00347607-1002	R:Metal Film 1/2 watt 1 ±25 ppm	Corning
R911	4.99K	RN60D4991F	P00347601-4991	R:Metal Film 1/2 watt 1%	Corning
R912	3.01K	RN60D3011F	P00347601-3011	R:Metal Film 1/2 watt 1%	Corning
R913	10.0K	RG1/4-103J	P00347620-103	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R914	220Ω	RG1/4-221J	P00347620-221	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R915	470	RG1/4-471J	P00347620-471	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R916	82		RC32GF820J	R:Carbon 1 watt 5%	TRW/IRC
R917	2.7K	RG1/4-272J	P00347620-272	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R918	15K	RG1/4-153J	P00347620-153	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R919	390	RG1/4-391J	P00347620-391	R:Metal Glaze 1/4 watt 5	TRW/IRC
R920	2.7		RC20GF2R7J	R:Carbon 1/2 watt 5%	
R921	470	RG1/4-471J	P00347620-471	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R922	4.7K	RG1/4-472J	P00347620-472	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R923-R924	15.0K		P00347617-1502	R:P00347607 Matched Pair to 0.2.	Interstate
R925	3.01K		P00347601-3011	R:Metal Film 1/2 watt 1%	Corning
R926	4.99K		P00347601-4991	R:Metal Film 1/2 watt 1%	Corning
R927	220	RG1/4-221J	P00347620-221J	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R928	10K	RG1/4-103J	P00347620-103	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R929	220	RG1/4-221J	P00347620-221	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R930	100		RC32GF101J	R:Carbon 1 watt 5%	
S1			P00347913	Switch, Rotary w/R003, Sweep Time (F44, F47)	Interstate
S2			P00347933-6	Switch, Toggle Sweep Ramp/ Freq Anal (F44)	Interstate
S3			P00347914-1	Switch, Rotary, Calibrator (F43, F41 Mode/Cal)	Interstate
S3			P00347915-1	Switch, Rotary, Calibrator w/R119 (F47)	Interstate
S4			P00347933-6	Switch, Toggle Lin/Log(F47)	Interstate
S5			P00347911	Switch, Rotary Multiplier, Var Sym/Norm/0.01F	Interstate
S6			P00347916-1	Switch, Rotary Mode w/R301 (F43, 44, 46, 47)	Interstate
S7		963		Switch, Pushbutton Manual Trigger	Switchcraft
S8			P00347905-1	Switch, Rotary, Waveform w/R248, R615	Interstate
S9			P00347910	Switch, Pull On w/R801, Offset	Interstate
S10/DS1		LPSW322-N-125CL		Switch, Slide, Power w/DS1 Indicator	UID
S11		SS-91-1-440.125		Switch, Slide Norm-Low	Stackpole
S12		SS-91-1 440.125		Switch, Slide, 230-115V	Stackpole
S13		SS-91-1 440.125		Switch, Slide, Isolation	Stackpole
S14			P00338750-2	Switch Assy Attenuator Nonrepairable, w/R804	Interstate
S15			P00347933-1	Switch, Toggle, Sync Out (F46 Only)	Interstate
T1			P00347808	Transformer Power	Interstate
VR701	6.8V	IN5235B	P00347350-068	Diode, Zener	Motorola
VR701	5.1V	IN5231B	P00347350-051	Diode, Zener	Motorola

Table 6-1. Parts List (Continued)

Ref. Desig.	Value	Alternate Part No.	Preferred Part No.	Description	Manufacturer
VR801-VR802	15V		P00347350-150	Diode, Zener	Motorola
VR901	12V	IN5242B	P00347350-120	Diode, Zener	Motorola
VR902	6.8V	IN5235B	P00347350-068	Diode, Zener	Motorola
VR903	6.2V	IN821	IN821	Diode, Zener, Reference	Transitron
VR904	12V	IN5242B	P00347350-120	Diode, Zener	Motorola
VR905	6.8V	IN5235B	P00347350-068	Diode, Zener	Motorola
			P00333100-12	Knob, Frequency (F41, F43, F44, F46)	Interstate
			P00333100-13	Knob, Frequency (F47)	Interstate
			PR0333021-9	Knob, Frequency Vernier	Interstate
			PR0336020-12	Knob, Pointer, Concentric Set	Interstate
			PR0336020-13	Knob, Pointer, Large	Interstate
			P00336020-16	Knob, Pointer, Small	Interstate
			PR0333142-2	Knob, Sweep Limit	Interstate
F1	0.375A	313.375		Fuse, 115V Operation	Littlefuse
F1	0.187A	313.187		Fuse, 230V Operation	Littlefuse
XF1		342022		Fuse, Post	Littlefuse
			PR0333029E	Drive, Planetary Ball	Interstate

NOTES

NOTES: 1. UNLESS OTHERWISE SPECIFIED,
1. ALL PNP TRANSISTORS ARE PO0947108 (2N3906)
2. ALL NPN TRANSISTORS ARE PO0947001 (2N3904)
3. ALL RESISTORS ARE IN OHMS ±5%, ¼W
4. ALL ±1% RESISTORS ARE ¼W
5. ALL DIODES ARE 1N4153
6. ALL CAPACITORS ARE IN μF.

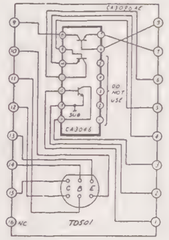
(1) INDICATED CAPACITORS MATCHED PER P00947750
(2) INDICATED CAPACITORS MATCHED PER P00947755
(3) INDICATED ±5 PPM RESISTORS MATCHED WITHIN 30Ω.
(4) INDICATED COMPONENTS ARE SELECTED IN TEST:

REF. DES:	APPROX. VALUE
C006	150 pf
E240	15K
R257	150K
C416	10 pf
C010	180 pf
C410	47 pf
C413	10 pf
C619	33 pf
R406	100Ω
C506	47 pf
C51C	3 pf
A2.C3	15 pf
A2.C5	15 pf.

(7) R401 - F43, F44, F47 3E.15%
- F46 6.8E ±5%
(8) R119 - F44 1E ±10%
- F47 10E ±10%
(13) R183 - F44 5.76E ±
- F41, F43 9.53E ±1%
(14) R256 - F41, F43, F44, F47 EE.1E ±1%
- F46 36.5E ±1%

(10) JUMPER WIRES ARE INDICATED BY SYMBOL J— WHERE A JUMPER SERVICES MULTIPLE BRANCHES, IT IS SHOWN AT THE NEAREST COMPONENT.

(10) CA3096AE SUBSTITUTE PART. I.E.C PIN P00340062:



SWEEP
REF. DES. 0XX
F44 & F47 ONLY
SWEEP TIME
S1-1A
S1-1B
SWEEP TIME VERNIER
SWEEP TIME CAL
Q2 P00947001
Q3 2N5770
Q4 2N5771
Q5 2N5836
Q6 2N5836
IC1 CA3030
IC2 CA3094AE
TC5 2ms/DIV
TC6 2ms/DIV
TC5 5ms/DIV
TC5 1ms/DIV
5V/DIV
SWEEP RAMP
FREQ. ANG.
S2
F44 ONLY
J2
F47 ONLY
J1
SWEEP SYNC
J3
LONG 100:1 SWEEP TIME
SWEEP MARKER CALIBRATOR
REF. DES. 1XX
USED ON F41, F43, F44 & F47
STEP CALIBRATE S3 USED ON F41, F43, & F47
SWEEP MKR
MARKER OUT J4
SWEEP MARKER
USED ON F44 & F47
SYNC IN
REF. DES. 5XX
USED ON F43, F44, F46 & F47
FREQ CONTROL
REF. DES. 2XX
USED ON ALL MODELS
LOG CIRCUIT
F47 ONLY
LOG LOW FREQ ADJ
LOG HI FREQ ADJ
LIN HI FREQ
LIN SWEEP HI FREQ ADJ
LO FREQ ADJ
LIN
LOG
VCF
J5
FREQ ANALOG
J6
STEP CAL LIMIT
F41 & F43
SWEEP LIMIT
F44 & F47
F44 ONLY
MULT@ 1.01
MULT@ 1.01
MULT@ 1.01
S5-2A
S5-2B
S5-2C
S5-2D
VAR SYM R48 25K
NORM HI SYM ADJ
NORM LO SYM ADJ
X.01F HI SYM ADJ
NORM HI SYM ADJ
NORM
.01F
LOGIC
REF. DES. 3XX
USED ON F43, F44, F46, & F47
TRIGGER LEVEL
TRIGGER SYNC
J7
MODE
S6-1A
S6-1B
MANUAL TRIGGER
S7
TC2 2V/DIV
5μs/DIV
START/STOP
REF. DES. 4XX
USED ON F43, F44, F46 & F47
Q1 1N5711
PHASE CONTROL
PHASE
FREQ MULTIPLIER
ALL MODELS
G5-1
X.1M FREQ ADJ
X.01M FREQ ADJ
Q5 P00947206
TRIANGLE AMP
REF. DES. 4XX
ALL MODELS
TP5
USED ON F41
TC2 5μs/DIV
2V/DIV
1V/DIV
5μs/DIV
VOLTAGE LEVEL SENSOR
REF. DES. 5XX
USED ON ALL MODELS
Q1 2N5771
SQ WAVE AMPLITUDE ADJ
SQ WAVE AMP. SYM
AMPLITUDE ADJ
AMPLITUDE SYMMETRY ADJ.
IC1 SN72741N
IC2 SN74H04
SQ WAVE OUT
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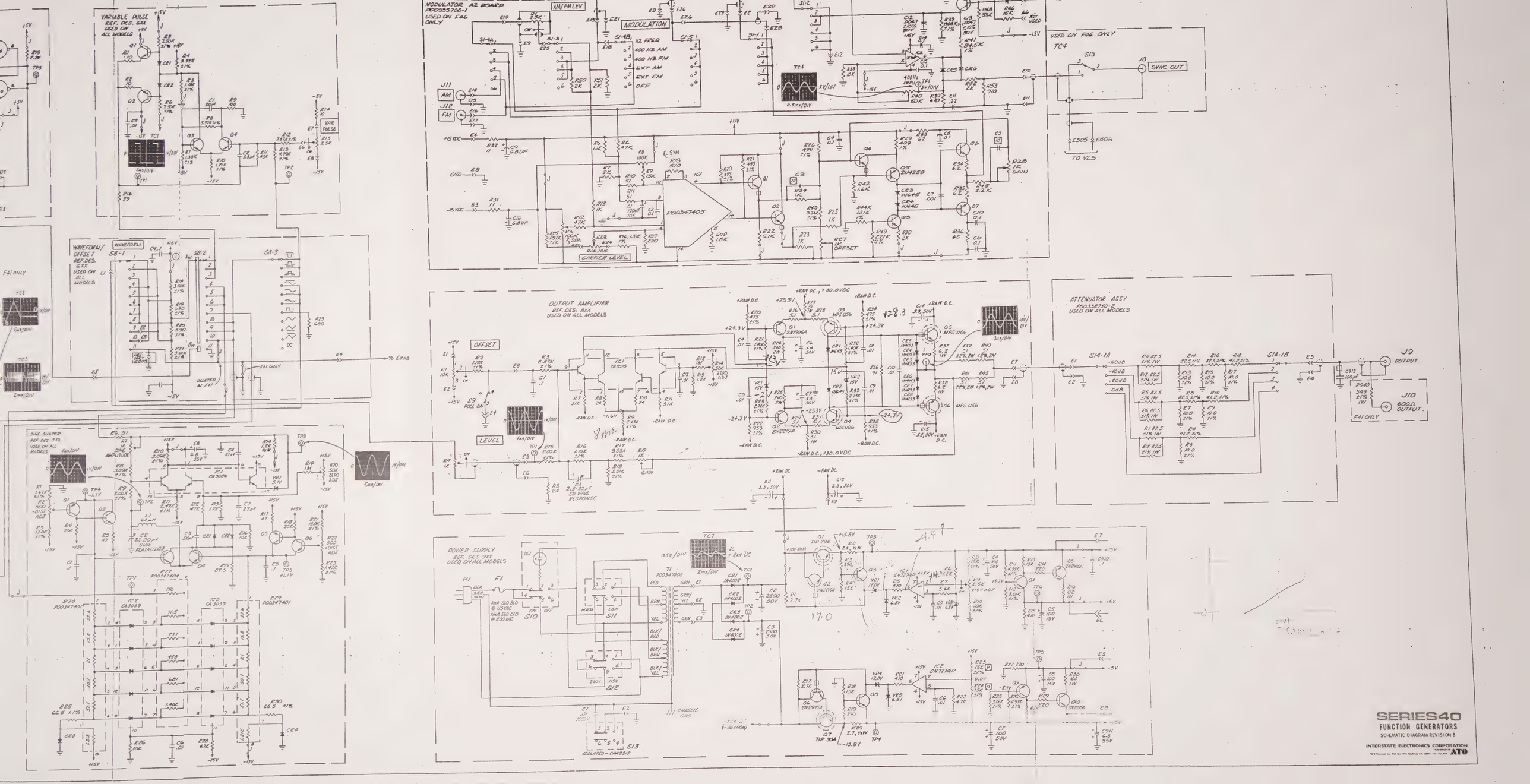
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USED ON ALL MODELS
WAVEFORM / OFFSET
REF. DES. CIX
USED ON ALL MODELS
MODULATOR A2 BOARD
P00033700-1
USED ON F46 ONLY
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AM/FM LEV
X2 FREQ
400 HZ AM
400 HZ FM
EXT AM
EXT FM
OFF
P00034705
CARRIER LEVEL
OUTPUT AMPLIFIER
REF. DES: BXX
USED ON ALL MODELS
OFFSET
LEVEL
ATTENUATOR ASSY
P00038750-2
USED ON ALL MODELS
SINE SHAPER
REF. DES. TXX
USED ON ALL MODELS
POWER SUPPLY
REF. DES. 9XX
USED ON ALL MODELS
USED ON F46 ONLY
SYNC OUT
TO VLS
SERIES40
FUNCTION GENERATORS
SCHEMATIC DIAGRAM REVISION B
INTERSTATE ELECTRONICS CORPORATION
ATO

ADDENDUM
FOR
MODEL F46 FUNCTION GENERATOR

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Section 1
INTRODUCTION/SPECIFICATIONS

1-1. INTRODUCTION

The F46 AM/FM Function Generator is a straightforward extension of the SERIES 40 Function Generator family. The primary modification is the addition of a printed circuit card (A2) to the basic configuration.

Information contained in this supplement refers only to the operational features and hardware contained on the supplemental printed circuit card designated A2 which is located beneath the large printed circuit card, A1.

The additional modes provided in Model F46 in no way affect basic operation of the instrument when the MODULATION switch is in the OFF position. Refer to the basic SERIES 40 Instruction Manual for all instructions and procedures other than those concerning the MODULATION features.

1-2. SPECIFICATIONS

The data sheet of Section 1-8 of the basic Series 40 Manual provides the specifications on the AM/FM F46 function generator.

NOTES

Section 2
OPERATING INSTRUCTIONS

2-1. OPERATING FEATURES

Figure 2-1 shows the location and describes the use of all AM/FM controls. This section is concerned only with the use of modulation functions as provided by the MODULATION switch. With this switch in the OFF position, the instrument operates as a standard F43 generator as described in Section 2 of the basic SERIES 40 Instruction Manual.

2-2. OPERATING NOTES

a. EXT FM MODE. - Inserts the AM/FM LEVEL control between an external voltage applied to the f-m connector and the voltage controlled oscillator circuitry. This mode is useful when the external f-m voltage level cannot be adjusted.

b. EXT AM MODE. - Inserts the modulation circuitry between the function generator waveform switch and the output amplifier. This mode provides both a-m and suppressed carrier operation as described in the following paragraphs.

c. AM. - Operation is achieved by rotating CARRIER LEVEL to establish an unmodulated carrier level. (The direction of rotation controls the carrier phase, either 0^{o} or 180^{o} .) The depth, or percentage, of modulation is controlled by adjusting the AM/FM LEVEL control. It is possible to overdrive the output amplifier in this mode, and care must be taken not to clip the waveform (which occurs when total swing exceeds ±10 volts peak into 50 ohms). Upon achieving the desired depth or percentage of modulation, peak-to-peak amplitude may be reduced by use of the main OUTPUT LEVEL and OUTPUT ATTENUATOR controls.

d. INT 400 Hz FM MODE. - Connects an internal 400-Hz free-running sinewave oscillator to the voltage controlled oscillator circuitry through the AM/FM LEVEL control. The carrier frequency will be frequency modulated about the point set on the main Frequency dial.

e. INT 400 Hz AM MODE. - Provides an internal sinewave modulating signal for a-m or suppressed carrier operation. No external a-m signal input is required.

f. 2X FREQ MODE. - Uses the modulator to multiply the carrier times itself. This is only meaningful (mathematically) to sinewave carriers for which the output is a sinewave of twice frequency, half amplitude and with d-c offset [$(\sin^2 x = 1/2 (1-\cos 2x)$]. To operate, turn the AM/FM LEVEL control full ccw, null the carrier with the CARRIER LEVEL control, then increase the AM/FM close to a maximum unclipped level. The output sinewave will be double frequency with the positive

peaks of the waveform at 0 volts dc. This offset may be balanced out by use of the OFFSET control.

2-3. SPECIAL APPLICATIONS OF EXT AM MODE

If a d-c voltage is applied to the EXT AM port and the CARRIER LEVEL control is set for a convenient carrier magnitude, variation of the d-c voltage will effect a voltage control of amplitude at the main output with a 100:1 amplitude range. Required polarity of the d-c voltage depends on the carrier phase selected by the CARRIER LEVEL control. If a sine-wave, having d-c offset with negative (or positive) peaks at 0 volts dc, is applied to the EXT AM port, and the carrier has been nulled by the CARRIER LEVEL control, an a-m waveform of 100 percent modulation will be produced whose amplitude is controlled by rotation of the AM/FM LEVEL control.

(1) Power Switch (All Models)
Rocker bar glows when power is switched on.

(2) Frequency Tuning Dial (All Models)
Tunes main generator over >1000:1 frequency range. Outer knob is 1:1 with dial scale (coarse adjust).

(3) Vernier Frequency Tuning (All Models)
Fine tuning control uses 6:1 planetary drive coupled to coarse tuning control.

(4) SWEEP/CALIBRATOR LIMIT Cursor (All Models Except F46)
Uses main frequency tuning dial graduations to indicate the upper limit to which the frequency will be swept or (stepped) by the internal Sweep Generator (F44, F47) or the STEP CALIBRATOR, respectively. Mechanically interlocked with the tuning dial.

(5) FREQUENCY MULTIPLIER (All Models)
Selects desired range multiplier for the frequency dial in six-decade steps when VAR SYM/NORM/.01f Selector switch (6) is in NORM position.

(6) VAR SYM/NORM/ x .01f Selector (All Models)
Three-position switch provides selection of one or two lower decades of main generator frequency range beyond those provided by the main FREQUENCY MULTIPLIER. Selection of VARiable SYMmetry automatically decreases output frequency by 10:1 and enables the VAR SYM Vernier (10). Selection of .01f position decreases output frequency by 100:1. Variable symmetry may not be used on this range.

(7) MODE Control
Provides selection of the modes in which the main generator may be operated:

a. CONTinuous (NORM on F41): An uninterrupted train of the selected wave form at the output.
b. TRIGgered (except F41): Generator starts at d-c baseline and produces one complete waveform cycle when enabled by an external trigger signal or the MANual trigger. Waveform ends at the original d-c baseline.
c. GATE (except F41): Same as triggered except that waveform cycles continue for as long as the external or MANUAL trigger is applied. The last cycle is always completed and ends at the original d-c baseline.
d. CALIBrate (except F46): Causes the main generator to provide a continuous train of waveforms at the frequency established by the SWEEP MARKER or by one of the 11 equally spaced points of the STEP CALIBRATOR (18). The lower and upper frequency extremes of the STEP CALIBRATOR (and the SWEEP MARKER on the F44, F47) are set via the main frequency cursor and the movable SWEEP/CALIBRATOR LIMIT cursor, respectively. In this mode the SWEEP MARKER control may be used as an independent frequency vernier or "bandspread" without disturbing the primary tuning controls. This is the mode that enables the STEP CALIBRATOR, and on the F41 the STEP CALIBRATOR is activated by the MODE switch on all positions except NORM.
e. CONTinuous SWEEP (F44, F47): Internally connects the ramp generator to frequency modulate the main generator via repetitive ramps (F47 provides a choice of linear or logarithmic sawtooth). Both generators are free running.
f. TRIGgered SWEEP (F44, F47): Both main and ramp generators are clamped to their respective baselines until enabled by an external trigger or the MAN trigger. Both begin simultaneously; the main generator sweeps from low to high frequency and returns to the d-c baseline without following the normal "retrace" of the ramp generator.
g. F46 MODULATION modes and the associated CARRIER LEVEL and AM/FM LEVEL controls are discussed elsewhere in the F46 portion of the manual.

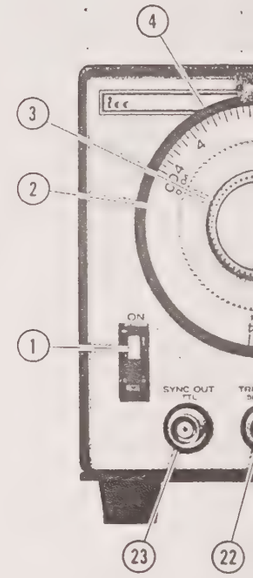
(8) TRIGGER LEVEL (Except F41)
Adjusts the level (-5 to +5 volts) at which an external d-c voltage will trigger or gate the generator(s).

(9) WAVEFORM (All Models)
Eleven-position switch provides selection between unipolar and bipolar versions of four basic waveforms (sine, square, triangle, and pulse) plus DC. All unipolar signals are approximately half the amplitude of bipolar signals and maintained tangent to zero volts independent of the OUTPUT LEVEL. All waveforms, including pulse, are available up to 4 MHz; however, the additional waveforms of bipolar and unipolar ramps may be created by selecting VAR SYM on control (6) in conjunction with the standard triangle waveforms and then adjusting the VAR SYM/PULSE WIDTH Vernier (10) at frequencies up to 400 kHz.

(10) VAR SYM/PULSE WIDTH Vernier (All Models)
This dual function control provides adjustment of waveform time symmetry (duty cycle) under either of two conditions: (a) selection of the VAR SYM position of control (6) and its attendant decrease in output frequency by 10:1 for any waveform or (b) selection of the NORM or x0.01f position of control (6) together with any of the pulse waveforms (see table 2-1).

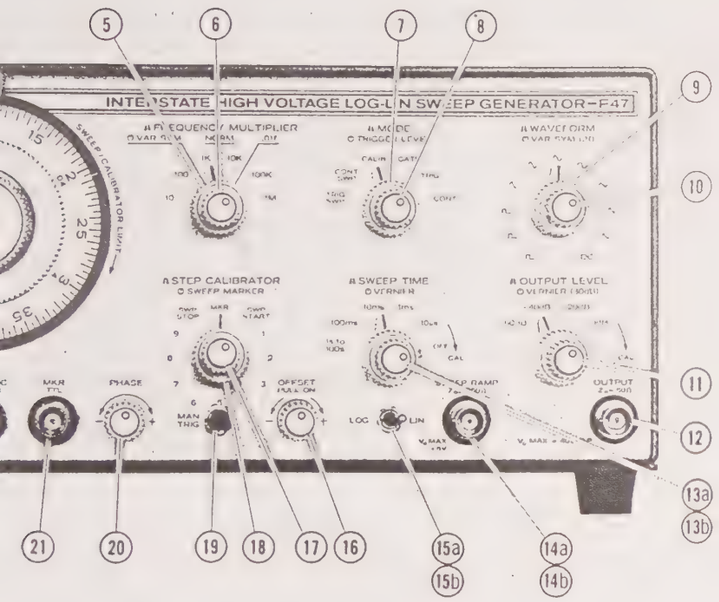
(11) OUTPUT LEVEL (All Models)
Four-position step attenuator and 30-dB vernier provide a maximum of 90-dB attenuation in overlapping ranges. Maximum output from the main generator is 40 volts peak-to-peak, bipolar into a high impedance. Since the internal source impedance is nominally 50 ohms, the maximum voltage into a 50-ohm load is 20 volts peak-to-peak (see 12).

(12) OUTPUT (All Models)
Main generator output for waveforms selected by the WAVEFORM switch (9). This and all other BNC connectors are nickel, corrosion-resistant and electrically isolated from chassis ground unless the grounds are connected via a rear panel slide switch. Fifty-ohm source impedance is standard in all models; however, a 600-ohm output is also made available in the F41.



(13a) SWEEP TIME Range (F44, F47)
Provides continuous contro
of frequency in five ra
numbers on the panel re
duration only; retrace tir
This unipolar (positive) ran
pletely independent test
fixed-amplitude outputs,
sync at 1 volt (rear panel)
front panel OFF switch.

(13b) MODULATION and Control (F46 Only)
In the F46 only this control
to the six-position MO
selector switch and its a
LEVEL vernier. See the F
elsewhere in this manual.



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(14a) SWEEP RAMP Output (F44, F47)
Fixed-amplitude output connector for the internal ramp generator (see 13a). This ramp is linear (even though LOG sweep may have been selected by control (15) so that it may serve as the X-axis drive for a plot on log paper.

(14b) FREQ ANAL Output (Except F46)
This d-c voltage equivalent to the actual frequency to which the main generator is tuned is a useful adjunct to frequency response plotting whether the frequency is being changed manually, by step calibrator, or by internal sweep. On the F47 the FREQuency ANALog is in the rear panel because of space limitations; however, on other models the connector is located on the front panel (see discussion on 15b).

(15a) LOG/LIN Selector (F47 Only)
Selection of the LOG position of this switch affects all tuning functions of the main generator. Thus, the main dial (2), VCF, and the internal sweep all provide logarithmic voltage to frequency behavior, and the FREQuency ANALog (14b) follows a logarithmic curve (exponential ramp when swept).

(15b) SWP RAMP/FREQ ANAL Selector (F44 Only)
The F44 replaces the LOG/LIN selector with a switch in the same location that permits the FREQuency ANALog voltage to be made available on the front panel.

(16) OFFSET Vernier and Switch (All Models)
Provides the ability to offset the d-c baseline up to the full swing of the output amplifier, with or without the presence of a signal so long as signal plus offset do not exceed ± 20 Vdc open circuit.

(17) SWEEP MARKER Control (F44, F47)
Continuously tunable control used in conjunction with either sweep mode in a two-step procedure to establish the exact frequency at which an event occurs in a device under test (DUT) after setting up the sweep conditions: a) connect the MKR output (21) to provide a trace on the scope or chart recorder in addition to or summed with the trace displaying the DUT response and adjust the negative-going MKR step to coincide in time with the event of interest. b) Change the MODE switch to CALIB position and measure the generator frequency at the SYNC OUT connector (23). This is the MKR frequency. The MKR is tunable anywhere between the swept band edges as established by the Frequency Dial cursor and the SWEEP/CALIBRATOR LIMIT Cursor. Thus, the MKR control can be used (in the CALIB mode) to manually tune the generator over a band of interest without disturbing the original sweep limits.

(18) STEP CALIBRATOR (Except F44, F46)
Provides the capability to tune through any preselected frequency band in 10 equal increments (11 points counting both band edges) without special technical skills or precision dial adjustments. Highly reproducible frequency steps are usable in increments as small a 0.1% of center frequency, or as large as 10% of a full three-decade range. May be stepped in either direction with uneven dwell times on each step. Each step number is labeled on the front panel and band edge calibration is built in. The STEP CALIBRATOR is enabled in the CALIB position(s) of the MODE switch and is independent of the presence or absence of any sweep functions; however, it operates between exactly the same band edges as the sweep and the MKR and can be used with the F47 LOG dial characteristic.

(19) MAN TRIG (Except F41)
Provides a means of manually enabling the TRIG and GATE modes (and TRIG SWEEP in F44, F47).

(20) PHASE (Except F41)
Active only in the TRIG, GATE, and TRIG SWP modes, the PHASE control permits continuous adjustment of the start and stop d-c baseline for sine and triangle waveforms. Approximately ± 90 degrees of adjustment is provided so that haversine (sine squared) and havertriangle functions can be generated as well as baseline-initiated ramps (variable symmetry triangles).

(21)(22)(23) Connector Cluster (All Models)
A triplet of BNC connectors with functions unique to each model as shown in table 2-2. The definitions of functions available in this cluster are treated below without regard to their specific location or use in a particular model:

VCF (Voltage-Controlled Frequency; called FM for the F46)
Accepts a-c or d-c voltage input to change the operating frequency of the main generator. Since this voltage is additive to the internal control signals from the Frequency Tuning Dial and the SWEEP RAMP, care must be taken not to exceed the tuning limits on any given range.

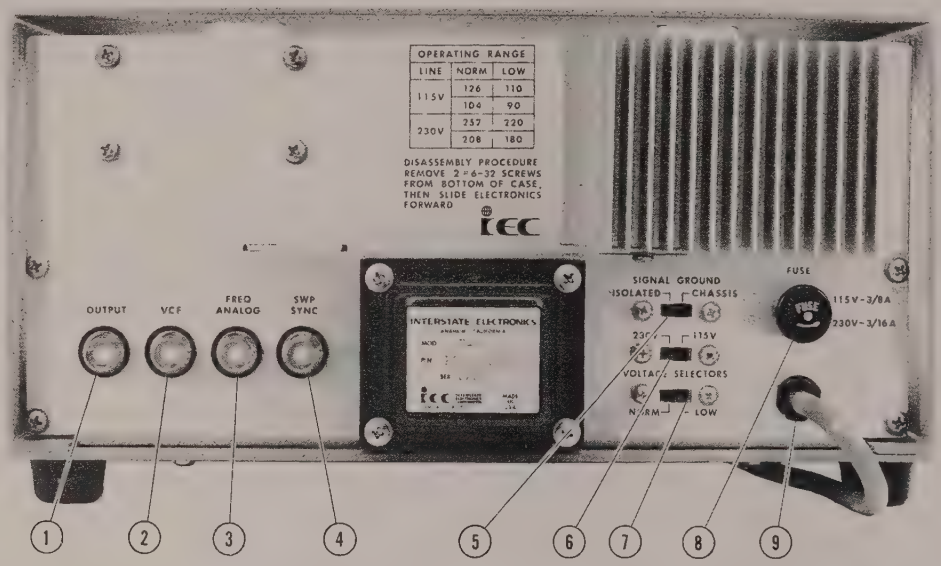
MKR Out
A TTL-level d-c voltage step that occurs each time the internal sweep ramp voltage is instantaneously equal to the reference voltage provided by the STEP CALIBRATOR or the SWEEP MARKER control. The step is negative-going during the ramp-up time and positive-going during the retrace time.

FREQ ANAL (Frequency Analog)
This output is discussed in (14b).

TRIG/SYNC
This dual-function input accepts external signals for triggering or gating the instrument, and in the CONTinuous mode accepts periodic signals to which the main generator may be synchronized when the two signals are within 1% of the same frequency. The external signal must be slightly higher in frequency for lock to occur.

SYNC OUT
This TTL-level rectangular waveform is available whenever the main generator is operating. It is a square wave unless VAR SYM (6) has been selected, in which case the SYNC OUT follows the symmetry of the main output signal.

Figure 2-1. Front Panel Controls and Indicators



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(1)(2)(3)(4) Connector Cluster

All models of the IEC SERIES 40 have provision for up to four BNC connectors in this area; however, the census of connectors actually mounted on the rear panel varies from model to model as described in table 2-2. Except for SWEEP SYNC, each of the connector functions was treated in the front panel discussion.

SWP SYN (F44, F47)

Low-level rectangular wave is intended primarily for recorder pen-lift control and/or scope synchronization. 0-to-1-volt open circuit and 600-ohms source impedance are present.

(5) SIGNAL GROUND Isolation Switch

Two-position slide switch permits single-point connection between the chassis (case) ground and the signal (circuit) ground used for all BNC connectors.

(6)(7) VOLTAGE SELECTORS

Slide switches permit the instrument to be operated from either 115 or 230 Vac nominal line voltage and, in addition, either NORM or low-line voltage variations can be accommodated. The table printed on the rear panel indicates the voltage operating ranges for the NORM and LOW switch settings.

(8) FUSE Post

Standard instrument line fuse is mounted here for easy access. CAUTION: be certain that the proper fuse value is placed before changing from 115V to 230 Vac and vice versa.

(9) Line Cord

The power line cord is permanently attached and has three wires.

Figure 2-2. Rear Panel Fuse and Connectors

Section 3
CIRCUIT DESCRIPTION

3-1. INTRODUCTION

Figure 3-1 is a simplified block diagram of the modulator subassembly board A2. (A complete schematic is shown on the main schematic in Section 5. The modulator circuitry is active in the EXT AM, INT AM, and 2X FREQ modes only. The waveform appearing at the WAVEFORM switch is wired around the modulator assembly in all other modes.

3-2. MODULATOR

The modulator is an integrated circuit (IC1) containing two differential pairs and two current controls wired as a balanced modulator. Pins IC 1-8 and 10, the base connections to the differential pairs, are driven by the main oscillator of the instrument. Pin 10 accepts the waveform unmodified; pin 8 receives the d-c average of the waveform. The modulating signal is introduced on pin 1, which is the current control for one differential pair. A d-c level obtained from front panel control R14, CARRIER LEVEL, is applied to the current control of the second differential pair. The differential output of IC1 appears on pins 6 and 12, riding on a d-c level of about +12 volts. Q1 and Q2 are emitter followers used to drive the amplifier.

3-3. AMPLIFIER

A noninverting differential amplifier (Q4 through Q8) having a gain of approximately 5 is required to (1) restore the gain loss in the modulator chip, (2) shift operating baseline from +12 volts at the modulator output (IC1 pins 6 and 12) to 0 volts dc, (3) provide common mode rejection for modulator drift, and (4) provide a low-impedance transmission line drive to the output amplifier of the generator.

3-4. 400-Hz OSCILLATOR

A Wein-bridge oscillator is implemented using operational amplifier IC2. The tuning elements are series C13 and R41, and parallel C12 and R39. Diodes CR5 and CR6 provide nonlinear gain elements. R40 is the amplitude adjustment. When the generator is used in the d-c mode and the MODULATION switch is inadvertently left in INT AM, noise will appear on the OUTPUT port. Q9 is provided to stop the oscillator whenever a logic signal appears on E5 or E6 causing Q9 to conduct.

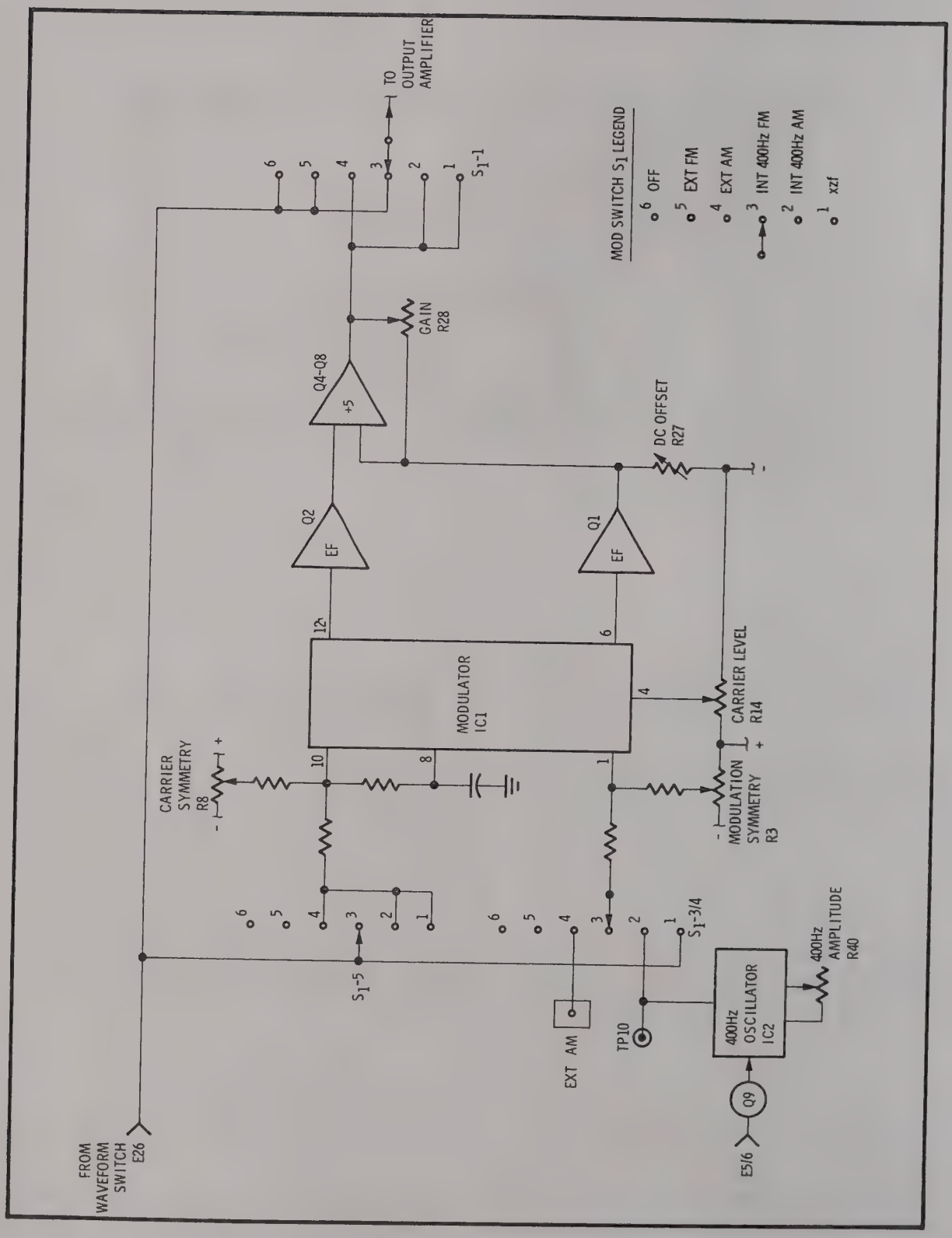

Figure 3-1. Simplified Block Diagram

Section 4
CALIBRATION

4-1. INTRODUCTION

This section contains the procedures for checking your Model F46 function generator for proper operation and/or for calibrating all elements of the instrument.

4-2. CALIBRATION

The sequence and methods of testing and calibrating the modulation section of the instrument are given in table 4-1 below. The necessary equipment is the same as that indicated in Section 4 of the basic SERIES 40 Instruction Manual.

TABLE 4-1. CALIBRATION PROCEDURE

STEP	CALIBRATION	SETTINGS OF CONTROLS	TEST EQUIPMENT (MODE)	PROCEDURE
1.0		FREQ DIAL @4 FREQ MULT @ X1K WAVEFORM @ ∿ MODE @ CONT MODULATION @ OFF	Oscilloscope	Adjust OUTPUT LEVEL VERNIER for a full scale oscilloscope display of ≈4V p-p at the OUTPUT BNC with peaks at graticules to be used for later reference.
2.0	fc Sym adjust	MODULATION @ EXT AM	Oscilloscope	Adjust R8 for the equal offset values corresponding to the CCW and CW stops of the CARRIER LEVEL control @ the OUTPUT BNC.
3.0	fs Sym adjust	MODULATION @ EXT AM	Oscilloscope	Adjust R3 for equal amplitudes corresponding to the CCW and CW stops of the CARRIER LEVEL control.

Table 4-1. Calibration Procedure (Continued)

STEP	CALIBRATION	SETTINGS OF CONTROLS	TEST EQUIPMENT (MODE)	PROCEDURE
4.0	Gain and Offset adjusts	MODULATION @ EXT AM	Oscilloscope	Adjust R28 and R27 for the waveform to fall between the reference graticules on the oscilloscope.
5.0	400 Hz amplitude adjust	SYNC OUT switch @ 400 Hz MODULATION @ INT FM AM/FM LEVEL @ CW stop	Oscilloscope	Adjust R40 for a 12V p-p sinewave at E13.

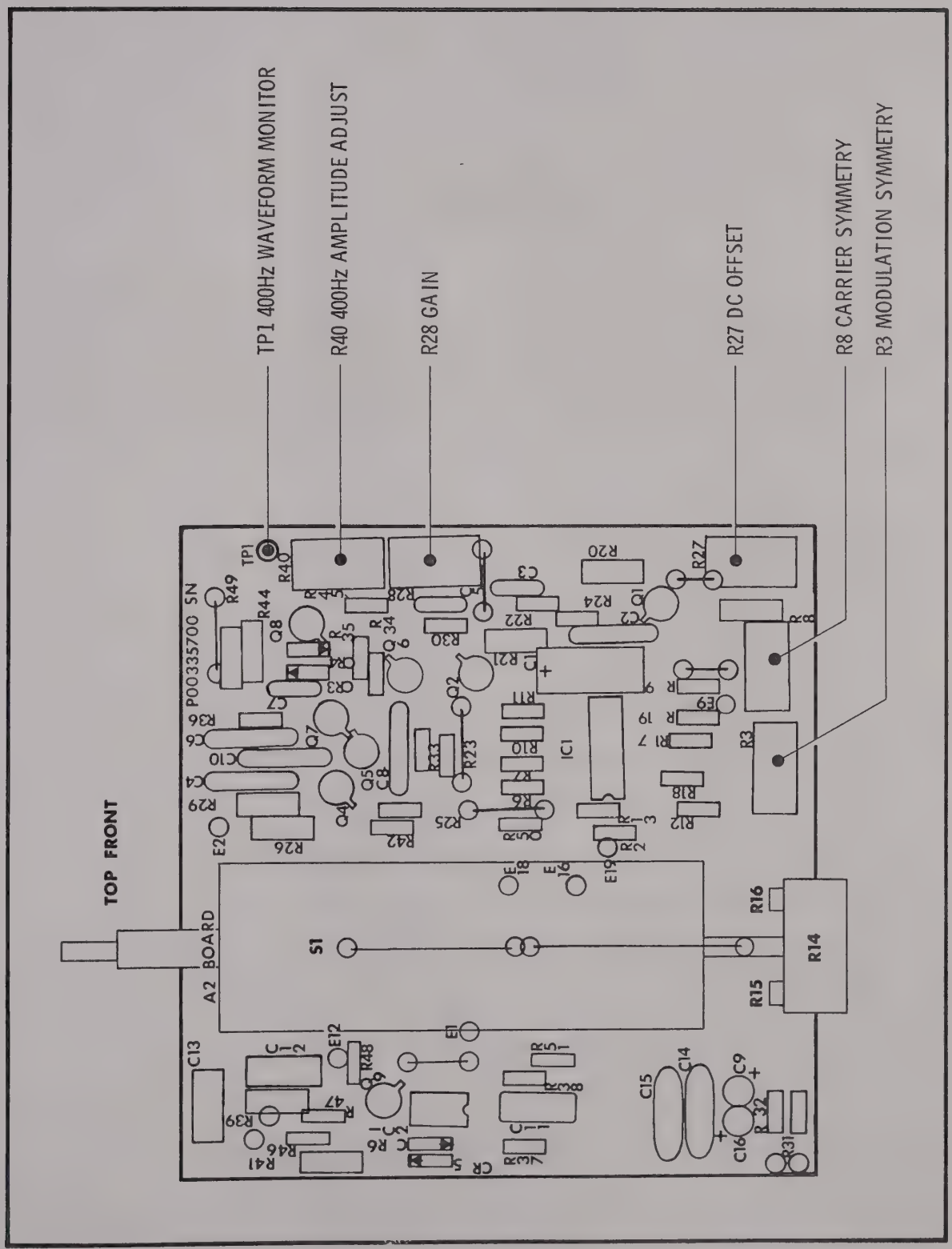

Figure 4-1. Adjustment Location Diagram

NOTES

Section 5
PARTS LIST

5-1. INTRODUCTION

All electrical and electronic parts are identified here, together with the manufacturers, whose code numbers are given in Table 6-1 of the basic SERIES 40 Instruction Manual.

5-2. PARTS LIST

Parts are listed by circuit reference number providing (a) value, (b) description, (c) manufacturers, and (d) original manufacturer's part number in Table 5-1 below.

TABLE 5-1. PARTS LIST

Ref. Desig.	Value	Alternate Part No.	Preferred Part No.	Description	Manufacturer
CR3-CR4		IN645		Diode	
CR5-CR7		IN914A	P0034730O	Diode	
C1	120MF	150D127X0010R2		C:Solid Tant, 6V ±10%	Sprague
C2	0.1MF	C280AEA/100K	P0034772I	C:Met Poly, 250V ±10%	Amperex
C3	15pf NOM	CM05ED-	Factory Select		Sangamo
C4	0.1MF	C280AEA/100K		C:Met Poly, 250V ±10%	Amperex
C5	15pf NOM	CM05ED-	Factory Select		Sangamo
C6	0.1MF	C280AEA/100K		C:Met Poly, 250V ±10%	Amperex
C7	0.001MF	C016A102G102M	C0168102G102K	C:Ceramic 1000V ±10%	Sprague
C8	0.1MF	C280AEA/100K		C:Met Poly, 250V ±10%	Amperex
C9	6.8MF	196D685X0035KA1		C:Tant, 35V ±20%	Sprague
C10	0.1MF	C280AEA/100K	P0034772I	C:Met Poly, 250V ±10%	Amperex
C11	0.22MF	C280AE/P220K	C280AE/P220K	C:Met Poly, 250V ±10%	Amperex
C12-C13	0.0047MF	192P4729R8	192P4729R8	C:Met Poly, 80V ±10%	Sprague
C14-C15	0.1MF	C280AEA/100K	P0034772I	C:Met Poly, 250V ±10%	Amperex
C16	6.8MF	196D685X0035KA1		C:Tant, 35V ±20%	Sprague
IC1		MC1496L	P0034740S	Int Circuit, Modulator	Motorola
IC2		SN72741P		Int Circuit, Op AMP	Texas Instruments
Q1, Q2		2N3904	P0034700I	Transistor	Texas Instruments
Q4		2N3904	P0034700I	Transistor	Texas Instruments
Q5		2N4258		Transistor	Fairchild
Q6		2N3904	P0034700I	Transistor	Texas Instruments
Q7		2N3906	P0034710Z	Transistor	Texas Instruments
Q8		2N3904	P0034700I	Transistor	Texas Instruments
Q9		2N3906	P0034710Z	Transistor	Texas Instruments
R1	2.5K		P0034769G-2	Potentiometer	Texas Instruments
R2	4.7K	RG1/4-472J	P0034762O-472	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R3	100K	TSV-100K	P0034767O-104	R:Trim 1/4 watt ±30%	CTS
R6	1.1K	RG1/4-112J	PG034762O-112	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R7	2K	RG1/4-202J	P0034762O-202	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R8	100K	TSV-100K	P0034767O-104	R:Trim 1/4 watt ±30%	CTS
R9	15K	RG1/4-153J	P0034762O-153	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R10-R11	51	RG1/4-510J	P0034762O-510	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R12	47K	RG1/4-473J	P0034762O-473	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R13	1K	RG1/4-102J	P0034762O-102	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R14	10K		P0034794Z	Potentiometer (see S1)	
R15-R16	1.37K	RN60D1371F	P0034760I-1371	R:Metal Film 1/2 watt 1%	Corning
R17	220	RG1/4-221J	P0034762O-221	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R18	510	RG1/4-511J	P0034762O-511	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R19	1.8K	RG1/4-182J	P0034762O-182	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R20-R21	499	RN60D4990F	P0034760I-4990	R:Metal Film 1/2 watt 1%	Corning
R22	5.1K	RG1/4-512J	P0034762O-512	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R23	5.1K	RG1/4-512J	P0034762O-512	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R24-R25	1K	RG1/4-102J	P0034762O-102	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R26	499	RN60D4990F	P0034760I-4990	R:Metal Film 1/2 watt 1%	Corning
R27-R28	1K	TSV-1K	P0034767O-102	R:Trim 1/4 watt ±30%	CTS
R29	499	RN60D4990F	P0034760I-4990	R:Metal Film 1/2 watt 1%	Corning
R30	2K	RG1/4-202J	P0034762O-202	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R31-R32	11	RG1/4-110J	P0034762O-110	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R33	62	RG1/4-620J	P0034762O-620	R:Metal Glaze 1/4 watt 5%	TRW/IRC

Ref. Desig.	Value	Alternate Part No.	Preferred Part No.	Description	Manufacturer
R34-R35	6.2	RG1/4-6R2J	P0034762O-6R2	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R36	62	RG1/4-620J	P0034762O-620	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R37	470	RG1/4-471J	P0034762O-471	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R38	10K	RG1/4-103J	P0034762O-103	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R39	84.5K	RN60D84R5F	P0034760I-8452	R:Metal Film 1/2 watt 1%	Corning
R40	50K	TSV-50K	P0034767O-503	R:Trim 1/4 watt ±30%	CTS
R41	84.5K	RN60D84R5F	P0034760I-8452	R:Metal Film 1/2 watt 1%	Corning
R42	1.6K	RG1/4-162J	P0034762O-162	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R43	3.74K	RN60D3741F	P0034760I-3741	R:Metal Film 1/2 watt 1%	Corning
R44	1.21K	RN60D1211F	P0034760I-1211	R:Metal Film 1/2 watt 1%	Corning
R45	2.2K	RG1/4-222J	P0034762O-222	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R46	15K	RG1/4-153J	P0034762O-153	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R48	33K	RG1/4-333J	P0034762O-333	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R49	2.21K	RN60D2211F	P0034760I-2211	R:Metal Film 1/2 watt 1%	Corning
R50-R51	2K	RG1/4-202J	P0034762O-202	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R52	2K	RG1/4-202J	P0034762O-202	R:Metal Glaze 1/4 watt 5%	TRW/IRC
R53	910	RG1/4-911J	P0034762O-911	R:Metal Glaze 1/4 watt 5%	TRW/IRC
S1			P0034794Z	Switch, Rotary Modulation w/R14 Carrier Level	Interstate

OPTIONS AND MODIFICATIONS

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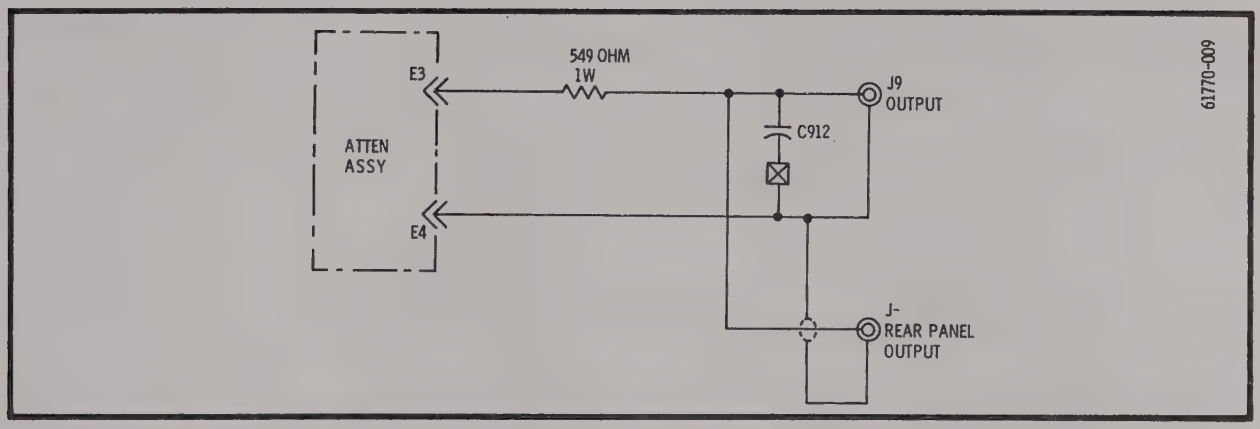
OPTION O
REAR PANEL OUTPUT



SPECIFICATIONS WAIVER: The addition of Option O to the F40 Series standard instrument causes a slight degradation in output waveform response at high frequencies and in particular the squarewave rise and fall characteristics at low amplitudes.

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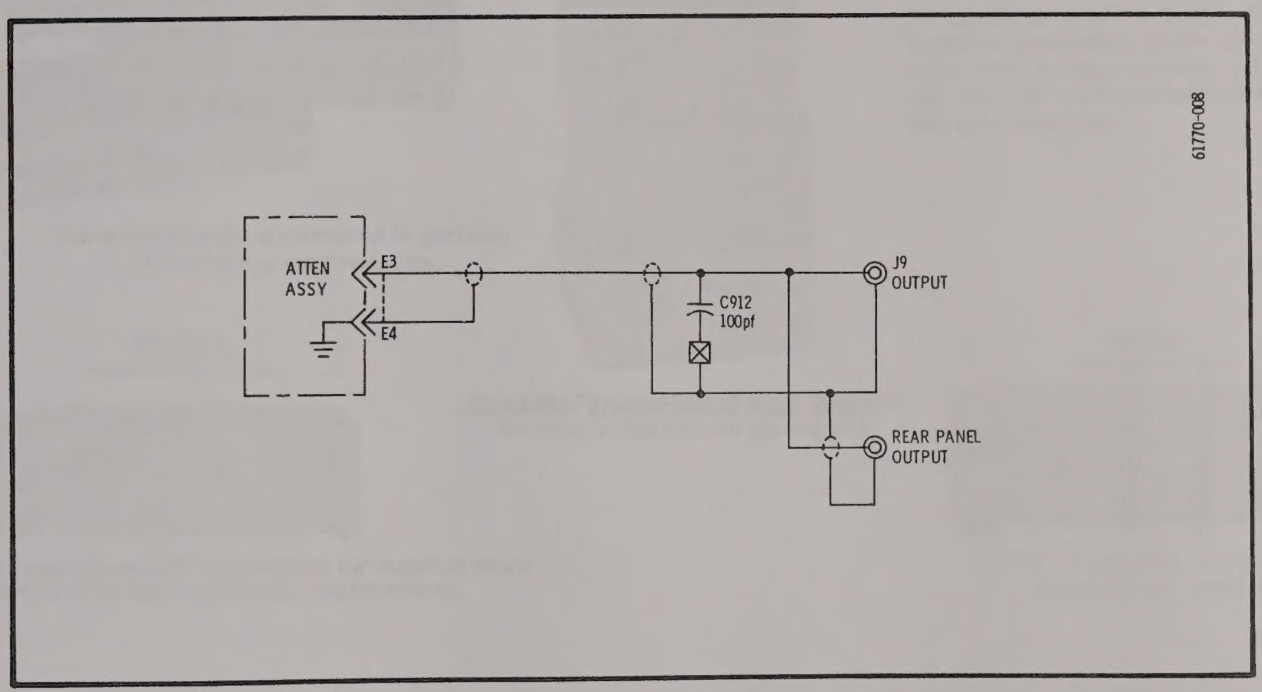
OPTION S
600 OHM OUTPUT IMPEDANCE



SPECIFICATIONS WAIVER: The addition of the 600-ohm output impedance option to the standard instrument causes degradation in high frequency output waveform response; particularly for square wave rise time, fall time and overshoot where improperly terminated transmission lines are used.

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